MACHINERY.

March, 1904.

HYDRAULIC-FEED FOURTEEN-INCH BORING LATHE.

THE powerful machine illustrated in Figs. 1 and 2 is a hydraulic feed 14-inch boring lathe recently built by the Niles-Bement-Pond Co. at the Niles Tool Works, Hamilton, O. It was constructed for the Midvale Steel Co., Nicetown, Pa., for boring forgings, marine propeller shafts, ingots and all other large work from which the core must be removed. This great lathe will take in a shaft having a maximum diameter of 30 inches and a length of 60 feet, and will bore a hole from the solid 12 inches in diameter the full length, or 14 inches diameter for short lengths. It attacks the work from both ends simultaneously and the maximum feed is ⅛ inch per revolution.

Obviously, two boring-bars are used, one at each end, while the work is being held in a hollow spindle or revolving chuck. Two revolving ring steady-rests on each side of the center chuck support the work. The feed pressure required to do such extremely heavy work is so great that it becomes impracticable to feed by rack and pinion or screw. For this reason the boring bars are fed in by hydraulic pressure. The boring bar itself is clamped in a head by means of hydraulic pressure, operating through a lever and toggle joint, which grips it with a pressure of 1,000,000 pounds. The hydraulic pressure against the piston is 720 pounds per square inch, giving the boring-bar cutter head a total pressure of 200,000 pounds against the work.

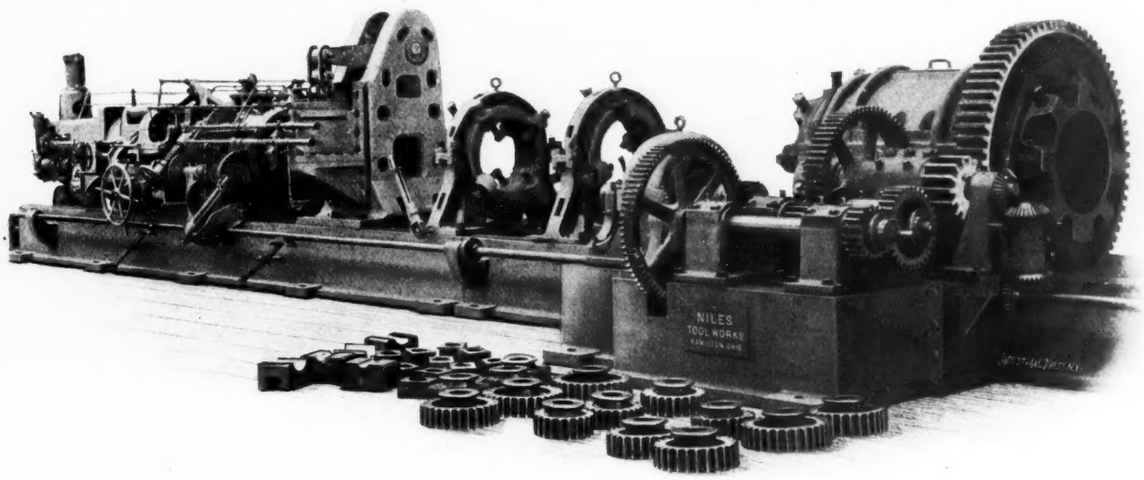


Fig. 1. Chuck and Driving Gear of Hydraulic Feed Boring Lathe, built by the Niles Tool Works for the Midvale Steel Co. Bores a 14-inch Hole from the Solid in Short Lengths and a 12-inch Hole from the Solid in 60-foot Lengths.

It is obvious that an arrangement like this, if using the unrestrained hydraulic pressure, would allow the tool to gouge into the work should the metal be soft, and, generally speaking, would not offer any means of control of the feed. In order to provide for this control the rear end of the piston, that is, the end projecting backward from the cylinder, is cut as a very steep sextuple screw, the lead being 18 inches. A bronze nut revolving on this screw has a worm-wheel with very steep pitch cut on its outer circumference. The angles of the screw and the worm are so chosen that the pressure against the piston will be able to revolve the nut, and the movement of the nut will be able to revolve the worm, but a relatively small amount of resistance on the worm will entirely check this movement. This amount of resistance is provided by ordinary feed mechanism taken from friction disks, which have the necessary change-gears, etc., to enable the operator to get any feed desired. It will be seen, therefore, that the hydraulic cylinder furnishes the pressure and the feed mechanism is never subjected to the heavy strains due to the exceedingly heavy work to be done on this machine.

Fig. 1 clearly shows the driving power of this machine. It is driven by a 100-horsepower Westinghouse motor, 220 volts. A motor of this make and size always allows of some speed variation by means of field control. The range of speed is increased by the change-gears, which are also shown in the illustration.

The main driving gear, which is bolted onto the hollow spindle or chuck, has 75 teeth, 4 inches pitch, 10 inches face. It is a steel casting, as is also the spindle. The hole in the spindle is 31 inches diameter. The piece to be bored is chucked by means of eight huge set-screws 3½ inches in diameter, on each side of the hollow spindle.

The feed is taken from the last driving-shaft, and is transmitted to the two cylinders by means of the long shaft running alongside and in front of the bed. This shaft is supported by drop-bearings and is made in three pieces coupled together. Change-gears and friction disks give a wide range of feeds. A hand feed is provided for by means of hand-wheel. Before using this hand-wheel, the friction disks and feed driving-shaft are disconnected by means of another hand-wheel. A 5-horsepower motor gives a fast motion to a train of gearing, whereas the feed mechanism gives a slow motion to the train.

A clutch-lever throws in either one or the other, and thus gives either a slow feed or a quick traverse of 10 feet per minute to the piston if the cylinder is clamped to the bed, and to the clamping head; or if the clamping head is clamped to the bed it gives this quick traverse to the cylinder. This quick traverse is really gotten by means of hydraulic pressure in the cylinder, and the small motor only regulates the speed. A hand-wheel gives adjustment to the piston and clamping-head, or to the cylinder should this latter be clamped to the bed.

The parts to be moved being very heavy, it is natural that a great amount of movement of the hand-wheel is required in order to produce a small amount of motion of either the clamping-head or cylinder, and consequently, if the cylinder is traveling at a rate of 10 feet a minute, by power, this hand-wheel would race at a terrific speed, which would be dangerous to the operator. For this reason the arrangement of the hand-wheel is made in such a way that the hand-wheel is loose on its shaft or stud if either the quick traverse or feed is thrown in, and is only connected to the mechanism which moves the cylinder when both feed and quick traverse are out of action, thus avoiding all possibilities of danger.

The train of gearing moved by the motor can be connected to the cylinder mechanism, or it can be connected to the shaft,

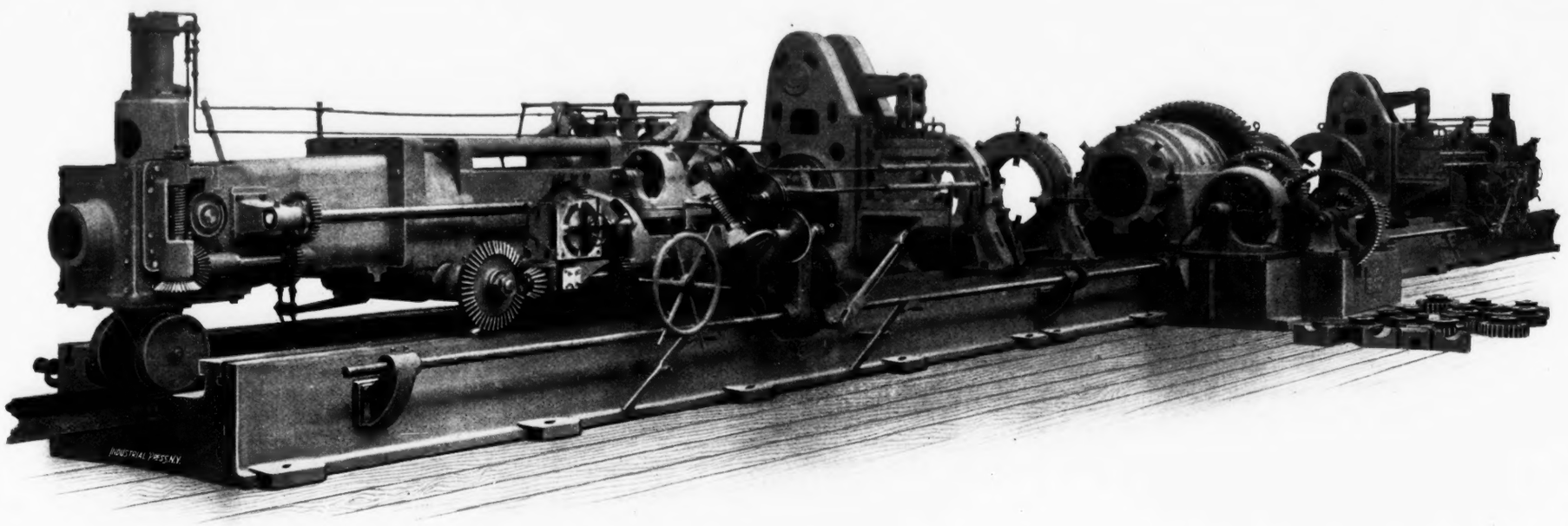


Fig. 2. Hydraulic Feed Boring Lathe. Length of Bed, 130 feet; total length of Machine with Boring Bars extended, 220 feet.

which, by means of suitable gearing, drives a grooved roll, not visible in the illustration, but which is held in a floating frame inside of the rear part of the cylinder casting. This floating frame carries the hydraulic cylinder, the piston of which is connected to the grooved roll while the cylinder casting is connected to the two other rollers under the bar. By admitting water in this cylinder the inner boring-bar is clamped between the rollers, and by moving the grooved roll a quick traverse motion is imparted to the inner bar.

The mode of operating the machine is to force 4 feet of the boring-bar into the work. By that time the clamping-head is up to the work and 4 feet distant from the cylinder. The quick traverse is then brought into play and the clamping-head is pulled back until it comes up to the cylinder. The inner boring-bar is then pushed 4 feet further forward and the boring-bar is once more forced into the work another 4 feet. This alternate action of forcing the bar into the work and drawing the clamping-head back so as to take a new grip is repeated until the center of the work is reached. Before setting up new work, whereby, of course, the position of the clamping-head and cylinder may have to be relocated, the following mode of operation is adopted:

Supposing the cylinder and clamping-head are near the center of machine and are wanted at the extreme end of the machine, then the clamping-head is first clamped to the bed and, by means of the quick traverse, the cylinder is pushed back 4 feet; the cylinder is then clamped to the bed, the clamping-head loosened and run back 4 feet. This cycle of operations is repeated as many times as necessary. The inner boring-bar can, of course, be withdrawn in one operation.

The piping for the different cylinders is at the rear of the machine supported in brackets or rollers where the piping slides. There are handles for operating the various valves both on the front and rear sides of the machine. The weight of the boring lathe without the boring-bar, is 360,000 pounds and its length is 130 feet. With the boring-bars extended as they are when starting to bore a 60-foot shaft the total length is 220 feet.

* * *

A novel plan for strengthening the Brooklyn Bridge so that it can safely carry greater traffic is proposed by Bridge-Commissioner Lindenthal. The present structure has a capacity of two railway tracks, two trolley tracks and two narrow roadways less than nine feet wide and a promenade for foot passengers. The present width of the structure is 86 feet; the width of the reconstructed bridge will be 105½ feet. The live load for which the bridge was originally designed is 2,000 pounds per lineal foot; the capacity of the reconstructed bridge is to be 11,000 pounds per lineal foot. It is to have accommodation on the upper deck for four railway tracks, and on the lower decks for two trolley tracks. There will be two roadways 17 feet wide each, and the footpaths will be at the sides, each 8½ feet wide. Briefly the proposed plan requires no additional cables and no additional load will be imposed on the tops of the stone towers. Stiffening frames are to be built in harmony with the present structure to carry the dead load of the roadway and the cables will only have to take care of the live load. These stiffening frames will be given fixed pier bending moments by means of hydraulic cylinders between the ends of the bottom chords where they will be in compression. The pressure on the pistons will be maintained constant so that the stiffening frames will always sustain a definite dead weight load.

* * *

A correspondent in a contemporary describes a method of making "inexpensive twist drills," it being substantially that employed by blacksmiths in making twist drills of the auger type. As a matter of fact, such drills will invariably be found the most expensive kind that can be used, when their weakness and inefficiency are considered, and it is not likely that any up-to-date shop superintendent would countenance the making and use of such drills unless it was for some job requiring special tools.

INJECTOR TROUBLES AND REPAIRS.

WITH SPECIAL REFERENCE TO LOCOMOTIVE INJECTORS.

FRED H. COLVIN.

Fred H. Colvin.

Injector repairs are more or less of a problem at best, and do not seem to be well understood in too many cases. To begin with, the engineer should report in detail just how a faulty injector works or fails to work. These symptoms vary widely and if carefully reported give a clue to the disease. It is very little assistance to be told "injector won't work," as this may mean one of a dozen things.

Remember that the maker ought to come pretty near knowing what is right in the way of tubes, and that it is a good plan to keep a set of new ones on hand just to measure from, if you have to clean scale out of the tubes, or to make new ones. On general principles it does not pay to make these; it is cheaper in the long run to buy them of the maker and keep them in stock for repair work. Of course the price seems high at times and we know the maker has his profit, but he knows how they should be made and has the tools for doing it. You can easily get the sizes from one set you buy, but it is not easy or cheap to make the proper tools for duplicating them. The sizes and the tapers have been determined by experience and are probably about right. Do not think that somewhere near this size will do just as well. It will not, and this is especially true of diameters of holes.

It is sometimes possible to clean out old tubes that have been scaled or pitted, if this can be done without materially changing the ratio of areas; but it is generally cheaper to put in a new set when they reach this condition. This may appear expensive but we must not forget that the injector is a very important apparatus. For unless the boiler gets its regular supply of water it is a case of drawing the fire, laying out the train and perhaps blocking the road, which would cost more than all the new sets of tubes needed for ten years on that engine.

It is pretty safe to assume that the injector is all right and that the trouble is with the piping or somewhere outside the injector proper. This is not always true, for tubes will wear out, especially if the water is bad or sandy; or they will fill up if the water is full of lime. In the latter case they can be cleaned out with tools or the scale dissolved in a bath of one part muriatic acid to ten parts of water. The safest plan is to have a testing plant where the injector can be taken right down and coupled up where it is certain the conditions are right. Then, if it does not work the injector itself must be examined. If it does work, as it probably will, you know the trouble is somewhere else.

A very convenient testing plant, and one that does not cost much to erect, is shown in Fig. 1. It can be readily adjusted for any size injector and is handy to operate. The writer has tested several thousand injectors in this way and knows that the plan is thoroughly practical. The sketch shows the essentials but does not show the beginning or ending of the pipes, as this will depend on the surroundings at each place. The water supply should be connected to a tank a little higher than the injector. An old cask, if it is large enough, will do nicely. This can be supplied from the city main, and it acts as an equalizer of pressure, so that injector gets the same water pressure at all times. Of course nearly all locomotive injectors are of the lifting type and do not require water to flow to them; but it is well to have this provision in all cases, as it enables one to test non-lifting injectors if one has to, and it is also handy to have with "lifters" at times.

With this the water can be made to flow to a lifting injector which has refused to work on the locomotive. If it works here with water flowing to it, one can feel pretty sure that the trouble lies in the lifting portion of the injector. By shutting off the water supply by a suitable valve and opening suction in the tank one can test the lifter. If it lifts but will not force water into the boiler then the trouble is evidently in the forcing tubes. We will refer to these symptoms in order later.

Steam comes in at the top, water comes up from the bottom and discharge goes out at the end marked. Each pipe which must be moved to suit different styles or sizes of injectors should have an expansion joint, as shown at *X X*. These are simply inner and outer sleeves, with the outer one carrying packing, as shown. Each expansion joint should have a locking rod, as indicated, to prevent forcing apart when pressure is on. A piece of ½-inch iron rod, bent to go around or over pipe and clamped as shown, answers very well and is cheap. In some cases it is also advisable to put in the expansion joint in the upright water pipe, but as a rule connections can be made of the right size for this.

Make the apparatus of the largest size pipe needed for your work—say, 2-inch pipes. Put the proper couplings in place at the end of the pipe by using a union on the end of the pipe and screwing the swivel and nut into this, as shown. For all smaller sizes simply make reducers, as shown at *a* and *b*. These are brass plugs which fit the large injector coupling nuts on pipes, threaded for the smaller sized swivels, as shown. These swivels can be made of just the right length to fit without expansion joints, if desired, but where a variety of injectors are tested the plugs will be found useful. Clamp *d* shows how the locking rods are held in position. Fitting *c* shows a connection for a type of injector where the steam connection is at the end instead of at the top. It fits into steam pipe and the injector coupling nut is on the angle valve.

Right here let me say that in the testing plant, as elsewhere, put on valves so that the pressure tends to open the valve. You can pack the valve easily and you can start the injector much more steadily. With pressure the other way there are sure to be times when the disk will bother by "taking up the slack" at the wrong time.

The discharge is an open question. If you can use it for washing out boilers or similar work, pipe it up to wherever you want. Unless you have use for it there is no need to pipe it anywhere but to the tank shown under the pipes. Have this run down fairly well in the tank to avoid splashing. This overflow should have a valve or stop-cock; so should the suction shown under the water pipe and used for lifting water from the tank. In the discharge somewhere put a pressure gage, *P*, and have a steam gage on the steam end to show the pressure you are getting, which should be about the same as is being used by the locomotives in order to tell just what you are doing—as injectors behave very differently at different pressures.

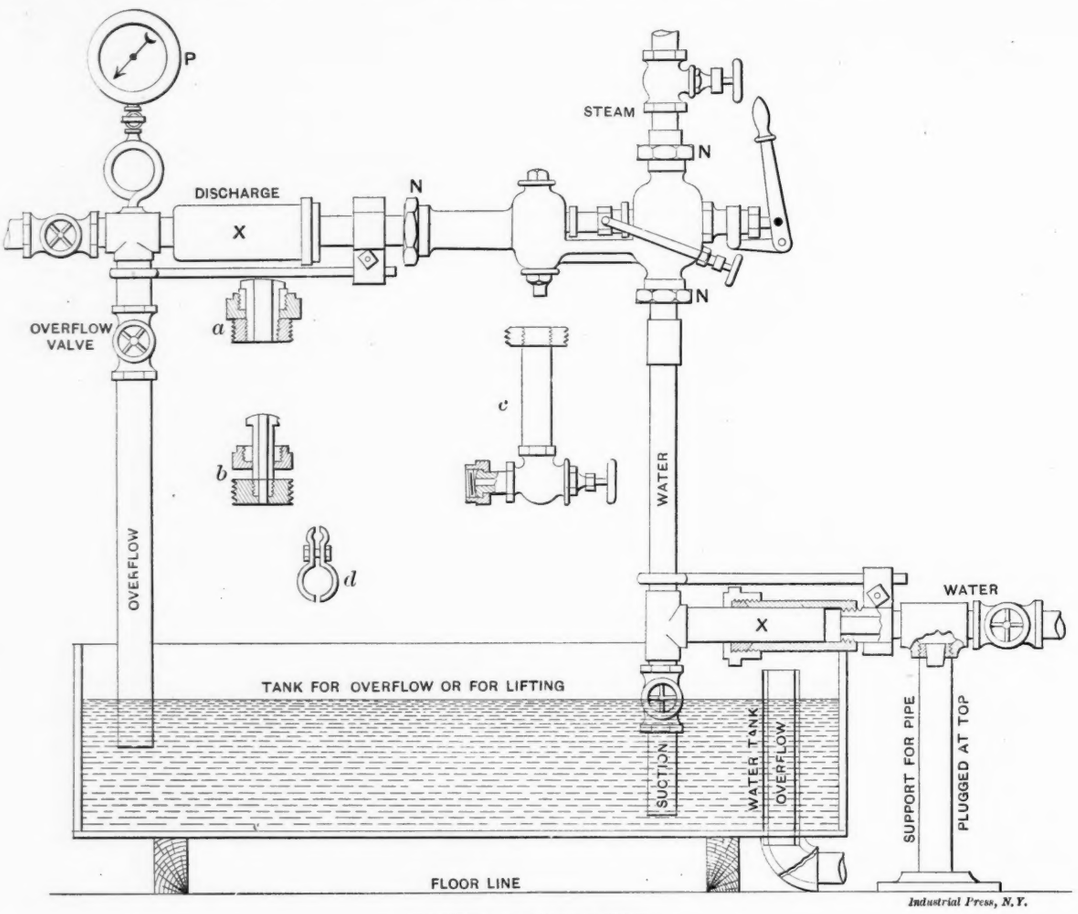
Now we will suppose an engine comes in with a balky injector. Take it off and put on a spare one, so that engine can go out at once if necessary. Take the cripple to the testing plant and couple it up. Close overflow and all valves except the steam, and put on full pressure and let it stay for a minute. This will show up any leaks in the body or in joints. Now shut off steam, open overflow, and run the water through, to cool off the injector. Open the valve in the overflow pipe and with the water flowing from the tank, open the steam valve and start the injector. If it starts, let it run and gradually close the valve in the overflow pipe. This will direct a pressure on the gage *P* which will show the pressure of water discharged. This should exceed boiler pressure about 20 per cent. to be safe in actual work, *i. e.*, a steam pressure of 100 pounds should be able to force against a pressure of 120 pounds on the gage *P*. The overflow valve should not be entirely closed, however, or the injector will "break," owing to the steam boiling the water in the tubes on account of having no place to force it. If the injector will not show the desired pressure on the gage, or if it breaks before reaching the pressure of the boiler, you can count on the tubes being worn out of proportion. And if you compare

them with your standard set of tubes you will probably find the discharge tube worn large in proportion to the steam tube. Or it may be that the mouth of the combining tube is cut out of shape.

If it works all right, you will expect to find the trouble in the lifting apparatus if anywhere. To ascertain this shut off the water supply, open the valve in the suction and try the lifter. In many cases this simply means the first pull of the injector lever. If it lifts all right and starts to work, you know the trouble is in the pipes or tank and not in the injector, and that the new one you put on will probably do no better than the one taken off. For this reason it is a good plan to test the injector at once and so find out whether to look for trouble in the pipes or not. Or if you try the new one after putting it on you are also informed in this respect.

This testing rig can be modified, elaborated or simplified to suit requirements. If you have only one style of injector some of the adjustable features can be omitted. If you wish to be 13,550 cubic inches, which must pass through ⅛ of a square inch in one minute. Dividing 13,550 by ⅛, which is really multiplying it by 8, we get 108,400 inches per minute, or (dividing by 12) 9,033 feet per minute. While this is a supposititious case it is not very far out for some cases, and when we consider that it means over 100 miles an hour, we realize that it is traveling rather lively.

With no intention of going into the theory of injectors it will be well to study the conditions necessary for them to work. Steam flows through the steam tube and mingles with the water in the mouth of the combining, or concentrating tube, as we may call it. The water condenses the steam which, of course, becomes water, and mingles with the feed. The incoming steam forces this through the tubes and more steam and water come in to take their place. As long as they are in the right proportion, the process is continuous and the injector "works"; change this proportion beyond the working limit and it "breaks" or "flies off."



Apparatus for Testing Injectors.

to test temperature of feed water and discharge, connect the thermometers with the water and discharge pipes as near to injector as possible. This will enable you to see the temperature of feed water, whether it is lifted or comes from the tank. If you want to test the lifting capacity, couple a vacuum gage on the suction so it can be connected in at any time. A regular gage or a mercury column can be used, but either should be graduated to read in feet. To test the capacity—have both tanks measured so that whether taking water from above or lifting it, you can note the time taken to empty the tank. If you are lifting water it will, of course, be necessary to have a separate discharge for the water so that it will not go back into the tank. In this connection it may be interesting to calculate the velocity of the water. Let us suppose that a No. 10 injector has a discharge tube with an opening 4-10 of an inch in diameter, which gives an area of ⅛ of a square inch. Suppose we find it throws 3,000 gallons an hour or 50 gallons a minute. Reduce this to cubic inches by multiplying by 231 (the number in one gallon), and we find it

The proper mingling depends on the amount of water, the amount of steam and the volume contained in the mouth of the combining tube, as well as on its distance from the steam tube. Then, too, experience shows that certain shapes are best adapted for the easy flow of the water, and these are used by the makers. Formerly the tubes of some makers were reamed with a curve taper, but straight-sided reamers are now used, as it has been found that they are practically as good and much cheaper.

All the steam admitted must be condensed or it will boil the water in the mixing chamber or blowback, causing it to break. If we use just as little water as possible and condense the steam, the water that goes to the boiler will be hotter than if we used all the water the steam would take up. So if for any reason you require hotter feed, "starve" the water supply all you can and still have injector work. This is practically what is done when the injector is run at its smallest capacity, and is one advantage of continuous feeding of the boiler rather than intermittent doses of cooler water. The efficiency

of the injector, however, from the standpoint of greatest amount of water thrown per pound of steam is much reduced. If we "starve" it too much, steam will not all be condensed, but will show at overflow and injector will break. If, on the other hand, there is too much water, the steam cannot force it all into boiler and the surplus will go out of the overflow, which somewhat cools the water delivered and also wastes the water. These few facts give us clues for analyzing symptoms and knowing where to look for trouble.

One of the simplest injector tests is to just look through the injector; very frequently a small piece of coal or wood lodges in the tubes and makes trouble. A few injectors have an internal check valve. This prevents looking through them but it will often be found profitable to take this out so as to have a look.

With the testing plant in good shape we know that there is no trouble with the pipes. If an injector starts and then breaks it is because conditions have changed. The only changes could be the heating up of the body; or water if used as a lifter, or the accumulated pressure in discharge being too much to force against it. If this is the trouble the overflow is not opened enough or the injector has not enough force or power This would indicate that the discharge tube was worn too large. If it comes from the heat, the injector is too sensitive and probably the steam tube is too large or the water passage is contracted.

If it wastes water at the overflow there is more water than the steam can handle or perhaps the tubes are not in line so that part of the water splashes out between the combining and discharge tubes, where these are separate.

Where it blows steam and then breaks, this indicates that there is not water enough to condense the steam. With the injector coupled on engine this is usually a signal to inspect the hose strainer, or the tank strainer, or both. If it starts all right and sputters and coughs, the symptoms indicate air in the suction. If there is much air it will break altogether. This is also sometimes an indication of an intermittent water supply caused by a piece of wood floating against strainer in tank, or waste temporarily clogging it. In stationary work this is sometimes caused by the injector being connected to the same source of supply as a pump. When the pump draws in a cylinderful the injector suffers and sometimes breaks. A case of this kind was very puzzling to the writer on one occasion, where the connection was not visible. An injector should always have a separate supply of both water and steam. The steam should be as dry as possible, as wet steam will not condense as readily in the combining tube and helps heat the water to the boiling point.

High-pressure steam requires more water or colder water to condense it, so that the steam tube can be smaller in proportion to the water supply. Some makers supply tubes for both high and low pressure. The difference is in the steam tube, which is smaller in the case of the high-pressure tubes. Low-pressure steam delivers much more water per pound of steam than high pressure. According to Kneass, the best authority on injector design and work, there should be about 29 pounds of water per pound of steam at 10 pounds gage pressure of steam, 16.6 pounds at 110 pounds gage pressure, and 8.8 pounds at 200 pounds of steam.

The heat of feedwater also affects both the lifting and forcing capacity of an injector. The distance an injector lifts its water also has a great effect on its capacity, simply because there is more work for the steam to do. With an injector which, at a lift of one foot, handled 14.5 pounds of water per pound of steam, this was reduced to 11 pounds at 10-foot lift, and less than 7 pounds at a 20-foot lift.

Here, as elsewhere in mechanics, it is simply a question of work done and energy expended. The injector combines mechanical work and transfer of heat. Whatever is lost mechanically is given up as heat to the water, the only real loss being the radiation from pipes and the injector itself.

Leaky check valves cause a lot of trouble in the injector line. They allow steam and hot water to flow back into the injector and make it difficult to start.

A little study of the proper conditions under which an injector should work will make it comparatively easy to guess somewhere near the cause of trouble. There's no mystery about it. If conditions are right it will work every time. A little judgment will soon show where to look for the trouble. Some makes are more delicate than others, and some parts wear or get out of adjustment very quickly. The repair man soon gets to know these parts. But in most cases you can count on the trouble being outside the injector itself. The feed pipe is especially apt to give trouble.

After an injector has been repaired or cleaned it should be given a thorough test, just as is given an air pump, and then you are sure that it is ready to be used in an emergency.

* * *

ENERGY OF WIND AND TIDES.

That large amounts of energy produced from natural sources are continually running to waste is, of course, well known to every engineer, but members of the general public as a rule entertain exaggerated and erroneous views of the commercial possibilities which such sources contain. Untrained imagination plays a large part in their estimation of physical phenomena, and prompts occasionally amusing suggestions in the way of power development schemes for professional friends. A large river moving steadily but slowly under an insignificant head impresses the general observer with a sense of majesty and power that is altogether out of proportion to the energy available, and it is not easy to convince him that an attempt at realization would be a commercial failure, and that for practical purposes it is not to be compared with the thin stream that comes down a hill in a 6-inch pipe under a head of 100 feet and operates a turbine at its base. The potential energy of such a pressure does not impress him. Actual kinetic energy is the only kind he understands. Hence he so often asks, "Why don't engineers use the energy of the tides for useful purposes?" and "Why do they not bridle the thundering waves?" only he recognizes that, like the wind, they are fickle. It is this uncertainty of action that to him alone accounts for the general absence of windmills, which are in his imagination giant sources of power, but, unfortunately, cannot be always depended upon, and hence are comparatively useless. His conceptions, however, of the real power capacities of these motors is lamentably weak, and he listens with a smile of incredulity to the statement that a 10-mile-an-hour breeze and a 25-foot wheel would probably not generate more than one horse power. He is equally surprised to learn that the positions where the necessary reservoir accommodation could be constructed so as to utilize the energy of the tides for power purposes on anything like a practical scale are exceedingly few, and even then, with the most favorable arrangement for securing continuous output and two storage reservoirs, only about two-thirds of the rise of the tide could be utilized, so that a tidal range of 10 feet would require about one-third of an acre of reservoir area for each horsepower produced. It requires, indeed, very little close reasoning to arrive at the conclusion that the places where the rise and fall of the tide can be used for power producing purposes are few and far between. They do not afford any temptation to resort to this method of producing useful work with advantage, and are likely to remain so as long as coal or other fuels can be obtained at present prices and converted into useful work by existing heat motors, inefficient though the process of conversion may in some senses apparently seem.—*Mechanical Engineer.*

* * *

The United States Consul at Pretoria, South Africa makes a report regarding American-built steam boilers that is scarcely flattering, to say the least. A firm imported an American steam plow at heavy expense and found after it had been examined by the official inspector of machinery that they would be unable to make any practicable use of the machine, simply because the inspector would not allow the rated pressure—140 pounds per square inch—to be carried. On account of the faulty construction 110 pounds was the maximum limit. Just previous to this incident it appears that nine new American boilers were rejected at Johannesburg as absolutely worthless. In the light of these facts it would appear that some of our boilermakers who are looking for foreign trade should bestir themselves and find what requirements must be complied with in boiler building for that trade. Not all governments are as indulgent in this matter as Uncle Sam.

TOOL MAKING.—4.

COUNTERBORES.

E. R. MARKHAM.

Counterbores are used for enlarging a hole without altering its location, and are made with a body part provided with cutting teeth, and a pilot. The pilot must be the same size as the hole to be enlarged, while the body must be of a size that will enlarge the hole the desired amount.

For making a counterbore for a few holes, or when it is necessary to make one as quickly and cheaply as possible, there is what is known as a flat counterbore, shown in Fig. 1. This can be so made as to require very little work in the machine shop, provided the forging is done carefully. After centering and squaring the ends the portions marked *A*, *B* and *C* are turned to a size a few thousandths of an inch larger

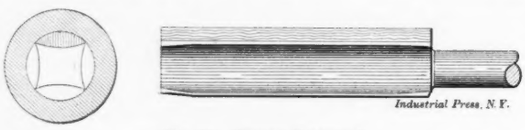


Fig. 39. Square Reamer.*

than finish; then the necked portions between the pilot *B* and the body *C* are made and the faces of the lips *D* squared. After this the portions *A* and *B* are finished to size with a file. The flat sides of the body *C* may be filed smooth, if there is but little stock to be removed; but if there is too much stock to file they may be milled with a shank mill such as shown in Fig. 2, the counterbore being held between the centers of the index head on the milling machine. One side of the body is milled, then the knee of the milling machine is lowered sufficiently to allow the counterbore to be turned one-half revolution so that the other side may be milled.

The sides *C* must be milled lower than the plane of the pilot in order that it may cut. At times it is considered desirable to mill the pilot on opposite sides to the thickness of the

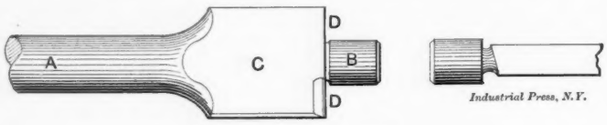


Fig. 1. Flat Counterbore.

body, and in such cases it is not necessary to lower the knee, because the carriage of the machine may be moved till the work is far enough away from the cutter to eliminate the danger of its hitting when revolving the work.

When the knee must be lowered to allow the counterbore to be revolved without touching the cutter, notice the reading of the graduated dial on knee elevating shaft, so that the work may be raised to the same position when milling the opposite side. An excellent way consists in turning the graduated collar to O, when the knee is at the proper height. This will be more easily remembered than 189 or some other number, unless we always turn the collar to that number. But since we are to habituate ourselves to setting to a certain number, why not use the natural one, which is zero?

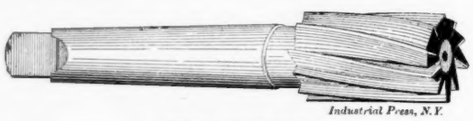


Fig. 2. Shank Mill.

The flat sides being finished we next draw-file the edges, removing a greater amount of stock on the back than on the cutting edge. This gives a slight clearance and prevents the tool binding when in use. We now file the cutting edges for clearance, as shown at *D* in Fig. 1, in order that they may cut. When giving clearance to tools of this character extreme care should be observed, for while it is necessary to carry the clearance to the edge, we must not remove any of the edge; for in all probability we would remove more stock from one tooth than another, and then the longer tooth would do all the cutting, and consequently the counterbore could not be made to remove stock as rapidly, neither would it last as long as if the teeth, or cutting edges, were of the same length and each did its proper amount of work.

It will be necessary to harden the pilot and body the entire length, to prevent their roughing up when in use. The amount necessary to draw the temper will depend in a great measure on the work the tool is to do. Ordinarily, however, it may be drawn to a full straw color (460 degrees).

If this counterbore were intended for permanent equipment we should leave it .010 to .015 inch large at *A*, *B* and *C* when turning, so that it may be ground to size after hardening. This

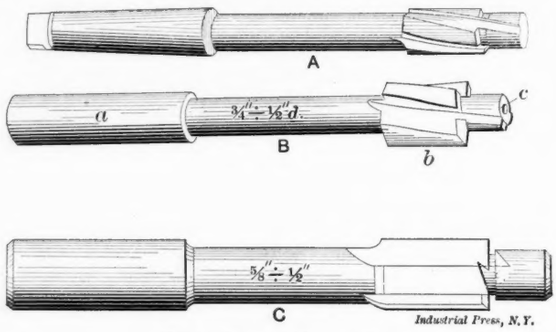


Fig. 3. Forms of Counterbore.

is not only necessary in order to get exact sizes, but to insure its being true; for when being hardened it would in all probability spring, and if it did, and there were no way of truing, it would run out of true. However, as this form of counterbore is usually selected on account of its cheapness it is not generally considered necessary to grind it after hardening.

When counterbores are wanted for permanent equipment it is advisable to make them of the form shown in Fig. 3. In this sketch *A* represents a taper shank counterbore having spiral flutes, *B* a straight shank counterbore with spiral flutes, and *C* a counterbore with straight flutes. The shank may be either straight or taper.

Counterbores for screw holes are generally made in sets. Each set contains three counterbores: One with the body the size of the screw head and the pilot the size of the hole to admit the body of screw; one with body the size of head of screw and the pilot the size of tap drill, and the third with the body the size of body of screw and the pilot the size of tap drill.

When centering stock to be used in making counterbores or similar tools do not use a large centering drill, or countersink very deeply. This would weaken the tool when in use and

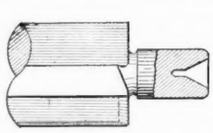


Fig. 4.

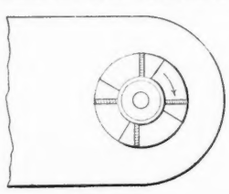


Fig. 5.

cause it to crack when hardened. If, however, through carelessness, or ignorance, a counterbore should be made having a center looking like Fig. 4 you can reduce to a minimum the liability of cracking when hardening by filling the hole with fireclay mixed with water to the consistency of dough. This should be allowed to dry before the counterbore is placed in the fire.

After squaring the ends the stock may be rough-turned to a size a little larger than finish—say 1-32 inch. If it is a taper shank counterbore the tenon may be milled or filed to size and the portions *a*, *b* and *c* at *B*, Fig. 3, turned to sizes .010 to .015 inch larger than finish, the portion *d* may be turned to size and stamped with the size of the body and pilot or any distinguishing mark desired. It is advisable when stamping articles of this character to use a V-block as a holder. Sometimes the inexperienced man will lay the tool on a piece of board or on the bench when stamping, and then wonder how it got sprung!

*This cut refers to the paragraph on square reamers in our last article, and was inadvertently omitted.

The next operation in order is the milling of the grooves that form the cutting edges of the tool. One method consists in cutting the grooves with a right-hand spiral of 10 to 15 degrees. Another method is to cut them straight. When cut with the spiral shown at *A* and *B* in Fig. 3, the chips are run back from the cutting edges and out of the hole, unless it is too deep. This spiral counterbore works nicely on wrought iron and steel, while the counterbore with the straight flute is generally considered more satisfactory on brass and cast-iron, but it also works well on wrought iron and steel.

It is generally thought best to cut the flutes of a counterbore so that the face of the cutting edge will be a trifle ahead of the center, rather than radial. This is especially the case

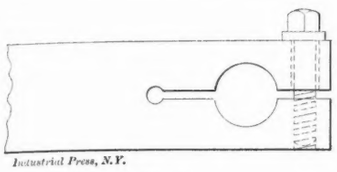


Fig. 6.

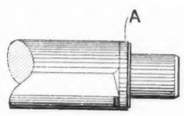


Fig. 7.

where the counterbore is to be used as a facing tool and it is desirable to produce a smooth surface. For a tooth facing ahead of the center, takes a scraping cut, and the tendency to tear the surface being cut is reduced to the minimum. The grooves in small counterbores are often made with a file, and in such cases it is best to make a spiral groove. A man accustomed to filing of this character can produce a nice cutting tool and at the same time a tool of good appearance by means of a round edge or a round file, and can file one or two small counterbores in less time than it would take for a milling machine to be rigged up and the job milled. However, when they are made for permanent equipment it is often considered desirable to have a uniformity of groove in the various counterbores, in which case it is best to mill them.

For most purposes counterbores are made with four cutting edges; small counterbores are often made with three, but unless the sizes are plainly stamped on them it is difficult to determine their size by measurement. Sometimes, however, small counterbores are given three and sometimes only two cutting edges. While large ones—especially those to be used as facing tools—are given more than four, the exact number cannot be arbitrarily stated; the nature of the work and the conditions under which they are used must determine this.

Generally speaking, the grooves should be cut below the

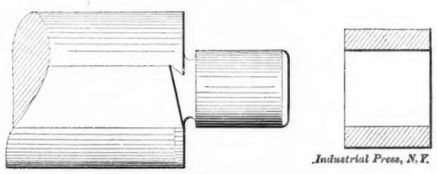


Fig. 8.

surface of the pilot, as shown in Fig. 3. By so doing we facilitate the operation of backing off the cutting edge for clearance. When cutting the grooves below the plane of the surface of the pilot the stops should be located on the carriage of the milling machine to give the proper length of flute; otherwise the grooves would be of different lengths, and while they might work as nicely as in a counterbore whose grooves were of a uniform length, they would not look well. And it is a fact known to most mechanics that a workman who is careless as regards the appearance of his work is very apt to be careless as to accuracy. It takes no longer to cut flutes of uniform length in tools, and it is advisable for a man to cultivate a taste for appearances that will not allow him to make an unsightly tool if it can be avoided.

When cutting the flute below the plane of the surface of the pilot, elevate the knee by means of the knee elevating shaft, and after cutting to the proper depth, the carriage is fed along to give the desired length of flute. Having milled one flute to the proper depth notice the reading of the graduated collar on the elevating shaft; or a better plan is to turn the collar until the line marked O will correspond with the line on the knee. Now lower the knee sufficiently to allow the counterbore to be turned to position for the next tooth. If the counterbore is long and slender it is well to support it when cutting the flutes, which may be done by means of the adjustable support furnished with all universal milling machines.

The flutes being cut, the next operation is to file the faces of the cutting edges to smooth them, so they may produce a smoother surface.

In order that the counterbore may cut, it is necessary to back off the cutting edges so it can penetrate the stock. This is usually done by filing, although in shops where counterbores are made in large quantities a machine is used for this purpose, and the backing off is done with a tool. To have this backing off accomplished in a satisfactory manner it is necessary, when turning the counterbore in the lathe, to neck down between the pilot and body, as shown in Fig. 4, which should be done with a tool whose corners are rounded, to prevent a tendency to crack when the counterbore is hardened. The amount of clearance given the cutting edges depends somewhat on the nature of the work to be done, but for general work an angle of 4 or 5 degrees will be found satisfactory.

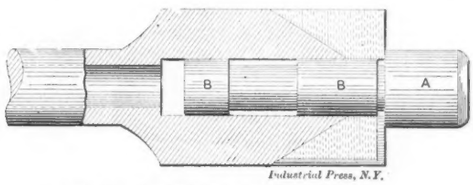


Fig. 9. Counterbore with Inserted Pilot.

With these counterbores, as with the flat counterbores, it is necessary when filing the cutting edges for clearance to make sure that the filing extends to the cutting edge, and that a keen penetrating edge is produced; but we must not shorten the tooth, as we could not shorten them all alike, and unevenness of length of tooth would result, the tool losing its efficiency thereby. This fact should be borne in mind when backing off any cutting tool having more than one cutting edge, and is especially noticeable in such tools as taps and screw thread dies. After hardening, the temper may be drawn to a light straw color if the tool is strong; if not, it must be drawn lower.

One thing should be remembered: The object attained in drawing temper is to reduce brittleness to a point where the hardened tool will be able to stand up when in service. Now the harder a tool is, the longer it will stand up between grindings, provided it does not crumble or break from brittleness.

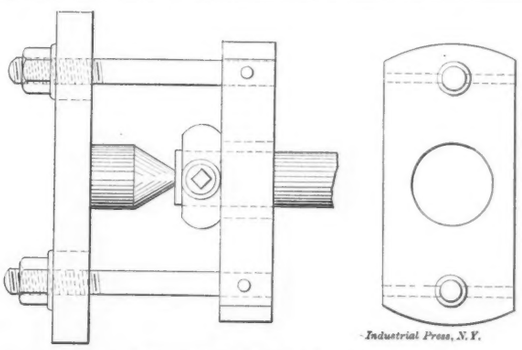


Fig. 10. Yoke for Fastening Work to Live Center.

Temper is drawn to prevent this breaking from brittleness; not that it is desirable to soften the tool, but to remove brittleness we are compelled to soften the tool. Therefore it is apparent that it is advisable to leave tools as hard as possible consistent with strength.

In years gone by, when emery wheels were not as common as they are to-day, it was generally considered good practice to draw counterbores and similar cutting tools to a full brown color, or even until purple spots appeared. This was done so as to make it possible to file the cutting edges, to sharpen them when dull. But this is a costly method of procedure and not the best practice where an emery wheel is available. It

is mentioned because there are times when even makeshift methods prove valuable.

Counterbores having slender pilots are liable to break, when in use, at the point where the pilot and body join. For this reason some mechanics consider it advisable to draw the temper of the pilot to a blue; but this is not generally considered good practice, as it is not possible to draw it so low at the point where it joins the body (and this is where they break) without drawing the temper of the cutting edges lower than is desirable. And drawing the balance of the pilot so low causes it to rough up when in use, especially if the material being cut is cast iron. So it would appear that this method reduces the efficiency of the tool without making it perceptibly stronger. To get the greatest strength possible the necking between pilot and body should be done with a tool whose corners are somewhat rounded, and when the tool is hardened it should be heated uniformly to a low red, and

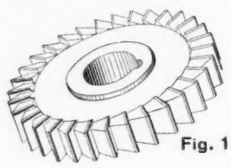


Fig. 13

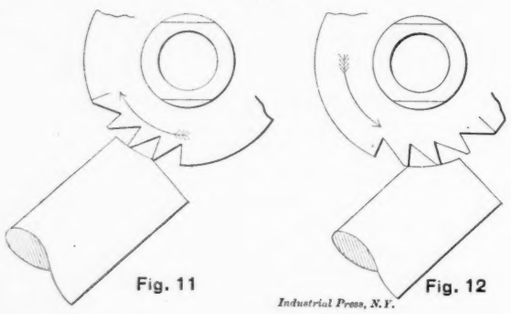


Fig. 11 Fig. 12

Industrial Press, N.Y.

dipped in a lukewarm bath. High heats, and careless, uneven heating are a source of much trouble when hardening, as they weaken the steel by opening the grain and render it unfit to do the work it might if it were treated properly.

Grinding Counterbores.—All tools which are held by their shanks and which must run true when in use, must have their shanks trued after hardening. Sometimes this is effected—if the shank is left soft—by turning in the engine lathe; but generally they are ground when grinding the balance of the tool. It is customary to grind the shanks first, as it is not advisable to place a dog on a finished cutting surface if it can be avoided. Then again, if the shank is to be ground straight it affords a better opportunity to set the machine so that it will grind straighter than when grinding either the body or pilot.

The shank may be ground to dimension given on drawing, or to fit a holder, as the case may be; after which the body may be ground. As a rule when grinding the body a sufficiently smooth surface may be produced by first grinding with a coarse or medium wheel to within .002 or .003 inch of size, then finishing with a fine wheel, exercising care not to heat the piece. But in cases where this method will not produce a sufficiently fine surface, the body must be left a trifle, say .0005 inch, above size, when ground with the fine wheel, and lapped to size. For lapping work of this kind run the counterbore in a direction opposite from that in which the tool runs when in use, there being then less liability to round the front face of the tooth. It should be run in the direction of the arrow in Fig. 5.

The form of lap used for this class of work varies according to the custom in the individual shop. When lapping cutting edges it is best not to use laps made of lead or other soft metals; the stock in the laps being soft yields and does not produce good work. Yet there are many places where lead laps are very useful. Cast iron being an open-grain metal, is charged very readily with abrasive material, and, being firm, will not yield; so for most work of this character it proves very satisfactory. Furthermore, it has the advantage of cheapness, which, while it should not influence us to the extent of selecting an inferior article, should always be a consideration when it answers the purpose as well and we have many pieces to make.

The lap may be a piece of scrap iron with a hole bored through it a trifle—say .001 inch—larger than the diameter of the piece we are to lap. It should then be split and a screw hole drilled and tapped in it, as shown in Fig. 6, so that it may be closed as the diameter of the piece being ground diminishes.

If emery is the abrasive material to be used in cutting the counterbore, it is generally considered best practice to use No. 120 emery for such work as that under consideration. As the tendency of laps is to cut a piece slightly smaller at the ends, the cutting end would probably be reduced enough smaller than the body to cause it to bind when the tool was in use, thus rendering it unfit for use. To overcome this tendency a short sleeve may be made and forced over the pilot up against the body of the counterbore, as shown at *A* in Fig. 7, after hardening and before grinding. This will prevent the cutting end being made smaller than balance of body. After the piece is lapped to size the sleeve may be removed.

As the friction incident to the lapping operation will cause the counterbore to expand, that is the diametrical measurement will be increased, it would be unsafe to gage it while warm. For this reason it must be cooled off before measuring. To effect this, use water that is at about the normal temperature of the room it is to be used in—70 degrees—as extremely cold water would cause it to contract more than it should, and when restored to normal temperature it would be slightly large.

When grinding the pilot the wheel should pass over the pilot on to the groove, provided it is thin enough. Should the wheel be too wide to allow of this it can be cut away on an angle on one side, leaving a narrow cutting surface. In fact, for the class of grinding incident to small tool work it is not advisable to have a very broad wheel surface on the piece being ground.

When machining holes of various sizes to a given size—all alike—it is not necessary to make a counterbore for each size hole; one tool may be made to do the work by having sleeves that fit various sizes of holes. The holes in the sleeves should all be of the same size and all should fit the pilot of the counterbore as shown in Fig. 8, whose body will produce the

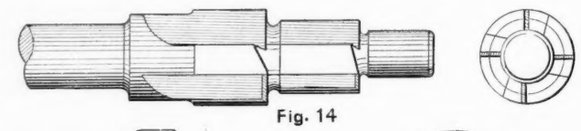


Fig. 14

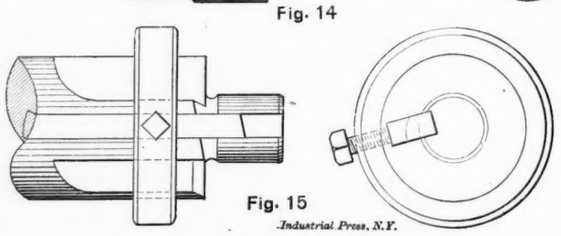


Fig. 15

Industrial Press, N.Y.

Figs. 14 and 15. Multiple Counterbores.

proper size of hole. One sleeve may be removed from the pilot and another substituted whose diameter corresponds with the size of the hole to be operated on. If these sleeves are intended for permanent equipment they should be made from tool steel, hardened and ground to size, but if only intended for one or two holes they may be made of machine steel and used soft.

Inserted Pilots.—The range of work possible with a counterbore is sometimes greatly increased by having pilots of various sizes which may be inserted as occasion requires. In Fig. 9 is shown a counterbore designed to take pilots of different sizes. This form of counterbore is oftentimes used where it is necessary to sharpen quite often, as the pilot may be removed and the teeth ground on their ends. If the teeth are ground on a universal grinding machine they can be kept very straight and square. After grinding, the pilot may be

again inserted and the tool is ready for use. Drill the hole all the way through the counterbore, to facilitate removing the pilot, as it may then be driven out with a set or a piece of wire. That portion of the hole that receives the pilot should be drilled, bored and reamed in the engine lathe. To accomplish this first square the ends of the piece, then turn a roughing chip over the outside. If the counterbore is large, anneal it at this stage, to do away with internal strains which will affect it when it is hardened. If it is small this precaution need not be observed. The end to receive the pilot should be run in the back rest, the opposite end being strapped against the live center.

The method of fastening work of this character against the live center varies in different shops. In some places they use yokes as shown in Fig. 10, which are made in several sizes to accommodate the various sizes of work to be done. In other shops it is customary to use a piece of belt lace. Before proceeding to strap the work make sure that the live center is a good fit in the taper hole in the head spindle, and that it runs true; then run the faceplate about one-half way off the thread on the spindle and run the lace around the dog on the end of the piece and then to the faceplate, running it back and forth several times. It is now tied securely. Then the faceplate is run all the way onto the spindle, thus creating a tension on the lace and drawing the work securely against the center. When fastening work in this manner care must be exercised that the lace does not draw unevenly, or the piece of work will not be drawn back against the center properly, but to one side, thus causing it to run out of true. For certain classes of work belt lace does not furnish a satisfactory means of holding work, but for most work it answers nicely if carefully adjusted.

If the hole to be drilled through the shank is to be done on centers, as is sometimes the case, it should be done before turning the outside of the stock, and before back resting for drilling the hole for the pilot. After drilling the hole as described, the end should be countersunk to provide a surface to run on the center when turning the piece to size. The hole to receive the pilot, however, should be machined by running the end in the back rest as described.

The teeth of counterbores of this description are usually made of the form shown in Fig. 9, so as to insure sufficient strength. It would not do to make them of the shape shown in Fig. 3, as the hole running through the tool would so weaken it that it would not stand up when in use. When cutting the teeth the counterbore may be held in the chuck on the end of the index head spindle. The head should be turned to an angle that will produce the desired shape of tooth when the cutter is fed through the piece. If the counterbore shows a tendency to raise and catch, from the action of the cutters used in milling the teeth when the cutting is started from the end, as shown in Fig. 11, the cutter may be reversed and the cut started from the opposite end of cut, as shown in Fig. 12. Under no circumstances must the cut taken be heavy enough to spring the piece. It is advisable to use a side milling cutter of the form shown in Fig. 13 when milling work of this kind.

The pilot should be made as shown in Fig. 9. The center of the portion that extends into the hole should be cut away as shown. After turning to a size .010 or .015 inch larger than finish size it may be hardened. The hardening should extend the entire length of the portion outside of the counterbore, and, as the hardening should never stop at a shoulder, it should extend a short distance onto the part that enters the hole. It may be drawn to full straw color. Grind the portion marked *A* to the designated size, and *B* to a force fit in the hole. It is apparent that on account of the nature of the tool it would not be advisable to force the pilot very hard; yet it must be forced hard enough to hold securely. After the pilot is ground to size it may be forced to place and the counterbore ground to size with the pilot in place, the pilot furnished the center to run on.

Multiple Counterbores.—Counterbores are sometimes made as shown in Fig. 14, in order that two or more sizes of hole may be made at one operation. At other times a groove is milled on one side and a blade inserted to cut a hole of a desired size. This blade is held in place by means of a setscrew and collar, as shown in Fig. 15. At times two or more grooves are cut and as many blades used. As it is necessary to have the faces of these blades radial, or a little ahead of the center —called a negative rake—it is apparent that the blades must be inserted in the slots and turned to reduce the back of tooth to the shape of the circle of the hole it is to enter when cutting.

Facing Tools With Inserted Blades.—A very simple form of tool used in facing surfaces when it is necessary to use a pilot, or guide, is shown in Fig. 16. This style of tool is often used to counterbore holes, and works very nicely where the amount of work to be done would not warrant a more expensive form of tool.

When but a small amount of work is to be done with the tool, it can be made of a piece of ordinary cold-rolled machine steel of the proper size. Drill a hole through it and ream with a reamer which will produce a hole driving size for some size of drill rod on hand. Cut off a piece of drill rod the right length, drive it in the hole and file it to correspond with shape shown in Fig. 16, to provide a cutting edge.

If the tool is to produce a flat surface, after driving the drill rod to place, back rest the end of the bar which forms the body of the tool and face one surface of the cutter square with body. Then drive it out, turn it sufficiently to give the necessary clearance, and face again to the shape shown in Fig. 16. Now take it from the holder, harden and draw to a straw color, and after replacing it in the holder the tool is ready for use. When using this form of tool for facing shoulders on work of the character shown in Fig. 17, the cutter must be made so that it can be easily inserted in, and removed from, the holder. In order to accomplish this the cutter must fit nicely in the hole, yet be free enough to allow of its being removed with the fingers, it being held in place by means of the setscrew shown in the end of the holder.

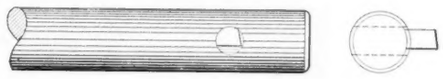


Fig. 16

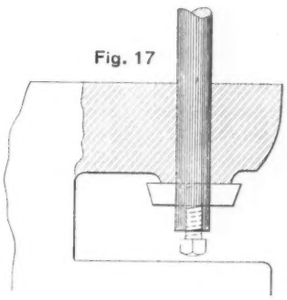


Fig. 17

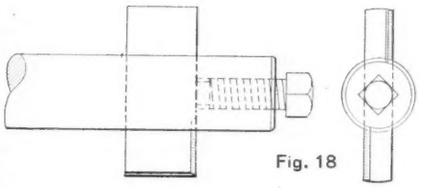


Fig. 18

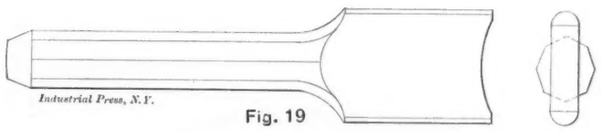


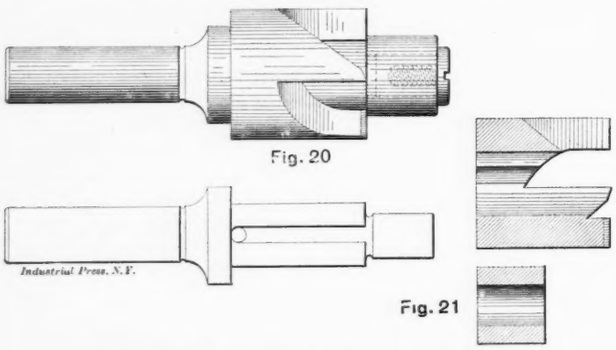
Fig. 19

Facing Tools with Inserted Blades.

Generally when this form of tool is to be used for permanent equipment the blade is made flat, as shown in Fig. 18. The hole in holder is drilled, broached and filed to size before the holder is turned to size as it would be apt to be sprung somewhat by the operation of cutting out the stock between the holes, this ordinarily being done with a broach called a drift, Fig. 19, which is forced through the holder with a hand hammer or an arbor press. The hole is finished to size with a file. The cutter is held in place by a setscrew, as shown. Various sizes of cutters may be used in one holder, and by using sleeves of different sizes on the pilot, the range of work possible with one holder is quite wide.

Combination Counterbores.—When there is a large range of sizes of holes, yet but few of one size to be counterbored, it is customary, if the holes are large, to make "combination counterbores," making one holder answer for several sizes of

cutters. With sleeves of various sizes having holes to fit the pilot at the end of holder, it is possible, by changing cutters and sleeves, to make one tool answer for quite a number of sizes of holes. Fig. 20 represents a combination counterbore, while Fig. 21 shows the holder and a sectional view of the cutter and the sleeve that goes on the pilot. The holder may be made of machine steel, and casehardened to prevent its being marred and to give it additional stiffness to prevent its springing from strain when in use. It should, of course, be left large enough all over to allow of grinding after it is hardened. When hardening it should be dipped in oil to prevent its springing and to make it as tough as possible. The tendency to spring if dipped in water would be very great on account of the key slot cut on one side to receive the key used to keep the cutter from turning when in use.

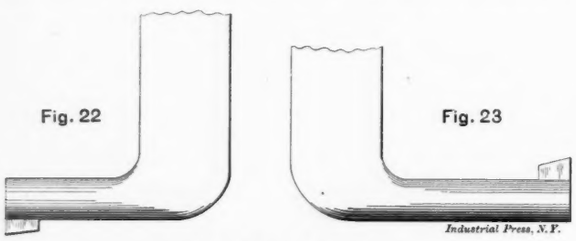


Figs. 20 and 21. Combination Counterbore and Holder.

When making the cutters use a good quality of tool steel, which should be cut into lengths a trifle longer—say 1-16 inch—than the finished cutter. The diameter of the stock should be sufficiently large to allow of the removal of all the decarbonized surface portion.

Place the blank in a chuck in the engine lathe and drill and bore a hole 1-16 inch smaller than finish size through it. After this place it in an arbor and remove the outside portion by turning. It should then be annealed. Right here many inexperienced men get into trouble; they either heat the piece of steel unevenly or allow it to "soak" in the fire, or else bury it in damp lime or ashes, any one of which leads to trouble. The steel should be uniformly heated to a red heat—not a bright red—then removed from the fire and allowed to cool very slowly.

After the steel is annealed it may be placed in the chuck and the hole bored and reamed to size; or if there is no reamer of the proper size it may be bored to required dimensions. The size to which the hole is machined depends on



Figs 22 and 23. Splining Tools.

the method to be adopted when the article is hardened. If it is to be "pack-hardened" it can be made to size; if, however, it is to be heated in an open fire and dipped in water in the ordinary manner, there should be left in the hole about .005 to .008 inch for grinding. When the hole has been brought to the proper dimensions the piece may be removed from the chuck and placed on a mandrel. The ends may now be faced to length, and the outside turned, leaving .012 to .015 inch for grinding.

In a former paragraph the term "arbor" was used to denote the cylindrical piece used to turn the blank on, while in the previous paragraph the word "mandrel" appears. The reason for this is that in certain sections of this country the word "arbor" is used to denote a tool of this character, while in general the term "mandrel" is employed. The latter term will generally be used in these articles when referring to a tapered arbor, forced into holes in pieces of stock, which are hereby provided with centers to turn on.

The spline cut, or keyway, may be cut with a splining tool, in the shaper or the planer. The ordinary form of tool used for this work is shown in Fig. 22. Experience has taught me, however, that best results will follow the use of a tool made as shown in Fig. 23, the difference being that the cutter is at the top instead of at the bottom. I have found this form of tool to cut faster and smoother than the other. Of course if tools like that shown in Fig. 22 are on hand in the shop it would not be advisable to make new ones, but if the tool has to be made I think that shown in Fig. 23 will give best results. Many times these tools are made with inserted cutters; these can be placed in the holder in either manner. After splining, remove the burrs, cut the teeth, and after stamping the size and any distinguishing marks on the cutter, it is ready for hardening; unless it is deemed well to drill and tap a hole for a setscrew, to keep the cutter up against the shoulder of the holder.

While cutting the teeth they may be held on an expanding arbor fitting the tapered hole in the spindle of the index head of the milling machine; or they may be held in the chuck which screws on the end of the spindle in the index head. After hardening and drawing the temper to a light straw color the cutter is ready for grinding. If the hole is to be ground to size the cutter is held in the chuck on grinding head, and by means of the internal grinding fixture shown in Fig 24 the hole is ground to size. After this it is removed from the chuck, placed on a mandrel and the outside is ground to the required dimensions.

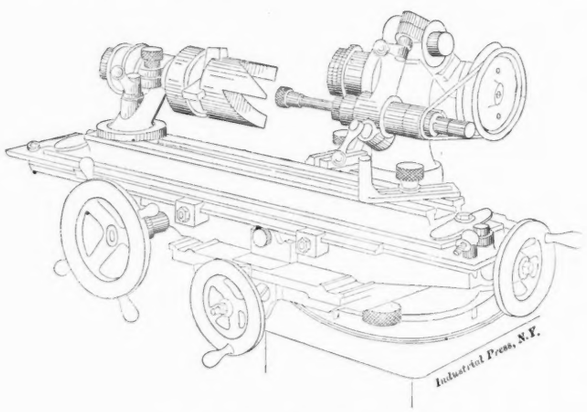


Fig. 24. Internal Grinding Fixture.

In grinding the cutting teeth for clearance the cutter is placed on a plug and the teeth are ground sufficiently to allow of their cutting. The amount necessary to back off the cutting edges depends on the nature of the work to be done and the stock to be cut. However, for most purposes an angle of 85 degrees from a line passing through the axis would be found satisfactory. If the teeth of the cutter were cut as shown in Fig. 20, that is the face at right angle with the ends, we could state the amount of clearance as being at a certain angle to the face of tooth; but as someone might cut them somewhat spiraling and then measure from the face, and get unsatisfactory results the measurement is given from an axial line.

Straightening Hardened Steel.—When counterbores, reamers, taps and similar tools spring from hardening it is possible to straighten them by applying pressure at the convex side. It is necessary, however, to heat the article somewhat before applying pressure, in order that it may become somewhat flexible and yielding. Pieces of steel having centers in their ends may be placed between the centers of a lathe and heated with a spirit lamp, Bunsen burner or ordinary gas jet until lard oil which has been rubbed on the surface commences to smoke from the heat in the steel; then pressure may be applied as shown in Fig. 25 by a tool or piece of steel held in the toolpost, which is forced against the work by means of the

cross-feed screw. The piece should be forced a trifle beyond a straight line; that is, it should be bowed just a small amount the other way. It may then be cooled with wet waste. When

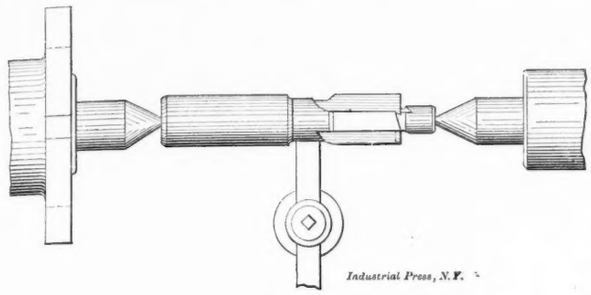


Fig. 25.

tested if it is still crooked the operation must be repeated until the piece is straight or near enough straight to grind all right.

* * *

BLOWPIPE METAL WELDING WITH ACETYLENE.

In a recent consular report United States Consul Halstead, of Birmingham, England, gives an account of the welding of metals by the use of acetylene in a special blowpipe. The following is an extract of the report:

"There is now on view in Birmingham an invention for the seamless welding of iron, steel and other metals by heat produced by the burning of acetylene with oxygen. With a special blowpipe, and the mixture mentioned above, the welding of iron and steel, etc., is done in the same way "as a plumber deals with lead." The acetylene is supplied in cylinders in a state of absorption by acetone, which has the property of dissolving ten volumes of the former for each atmospheric pressure, thus obviating all danger that has hitherto existed in the compression and storage of acetylene. The separate gases are passed through valves, which reduce the initial pressure in the cylinders to about 7 pounds per square inch on the blowpipe. The acetylene when ignited produces an intensely luminous glare, which vividness disappears when mixed with oxygen, there remaining a small, greenish-blue flame, which is adjusted to the proper dimensions for producing the greatest amount of heat. The heat zone is practically only about one-eighth of an inch in length, but the temperature is so great that after a very short space of time the metal, wherever it comes in contact therewith, is reduced to a molten state and coalescence follows. Even quartz, it is stated, can be melted as quickly and blown like glass.

"Among the pieces of work done by this process was the welding, instead of riveting, of a sheet of metal intended to form the body of a foot warmer for railway cars—the joining of two pieces of metal which when rolled out cold into half thickness gave not the slightest indication of a joint. In order to test the strength of joints experiments with compressed gas cylinders have been made; these, about 6 inches in diameter, with longitudinal and circumferential seams at the ends and also a boss welded in the center, withstood a pressure of 2,000 pounds to the square inch. Although the heat produced by the fusion of acetylene and oxygen is so great, operations can be performed with the naked eye." The many uses to which blowpipe welding may be put, if successful as outlined above, make this discovery one of great value in the mechanic arts.

To supplement the above information we have secured from the Commercial Acetylene Co., 80 Broadway, this city, a brief statement with regard to the use of acetylene for welding purposes as practiced by them. A representative of MACHINERY recently saw at their factory at Harrison, near Newark, N. J., a demonstration of the intense heat of a blowpipe flame in which acetylene is the combustible agent. The acetylene is stored in tanks in which it is absorbed by acetone which has the peculiar property, mentioned above in the consular report, of absorbing several times its own volume of acetylene, and in which state the stored acetylene is said to be entirely safe to use for manufacturing or lighting purposes. One cubic meter of acetylene ($C^2H^2=26$), weighs 1 kilogram, .165, and contains in weight 92.3 per cent. of pure carbon, and yields 14,340 calories, which make 12,300 per kilogram. At the moment of entering into combustion, it is dissociated in the following elements: Carbon and hydrogen. In producing by this action 2,600 calories, the balance of the heat is furnished by the combustion of the carbon in carbonic acid and of the hydrogen in water vapor.

The theoretic proportion to insure a complete combustion of a mixture of acetylene and oxygen is, one volume of acetylene to 2½ volumes of oxygen. Recently a burner of the Bunsen type was devised by Mr. Edmond Fouche, of Paris, France, which is called "Oxy-acetylenique," which gives a flame of one volume of acetylene and 1.7 oxygen. The flame obtained from this burner presents in its center a very short and sharp point, on the extremity of which the excessive temperature obtained is above 3,000 degrees Centigrade. In this zone the flame is composed almost exclusively of oxide of carbon and of free hydrogen, whereby a fusion of metal without oxidation is obtained.

A great many large factories in Europe are employing this for welding purposes, finding it very much cheaper than the process used before; and it is also a great deal more convenient.

* * *

MANUFACTURE OF FIREARMS IN BELGIUM.

The manufacture of firearms, complete or in part, is the traditional industry of the province of Liege, Belgium. Whether the people of Liege hold the secret of turning out a prime quality of gun barrel or other integral part of the arm, the U. S. Consul at that city does not know, but it is an established fact that no other barrel of corresponding make and value can stand the strain of the severe test put upon it as well as the Liege gun barrel. Every barrel must, under the law, successfully withstand the government test before it is admitted for sale. The gun barrels are made by the workmen in their own homes, and are delivered to the merchants, who combine the parts for the markets. It is said that no less than 50,000 men, women, and children are engaged in the manufacture of gun barrels. This system of buying from the people lessens the responsibility of the manufacturer, for if the barrel fails to withstand the test the workman and not the manufacturer is the loser. The material for manufacturing the gun barrels or other parts of firearms is oftentimes supplied by the manufacturer, who sometimes gets his barrels roughly made and completes them himself.

It is the universal understanding here that the United States is the best market for the cheap grade of guns, and there is a double-barreled gun called at Liege the "American." It is estimated that in the Province of Liege about 150,000 pairs of gun barrels were manufactured during the year 1902, part of which were sent to the United States rough bored, to be finished. The exportation of gun barrels of all grades to the United States is increasing. During the six months ended August 31, 1903, there were exported to the United States firearms to the value of $234,815.71 and gun barrels to the value of $39,012.33.

Quite a controversy exists as to the better quality of gun barrel—the Damascus or the steel. The Damascus is manufactured only at Nessonvaux, near Liege, while the steel barrel is made in Liege. One argument in favor of the Damascus barrel is that in case of an explosion there is less liability of injury than with the steel barrel. Muzzle-loading guns are sent in large quantities to South America, while the flintlock is made for export to Africa. Revolvers are turned out in great numbers and are shipped to all parts of the world. It is estimated that 600,000 were manufactured in Liege last year.—*Consular Report No.* 1862.

* * *

It is not only important to know how many hours a man works on a particular job; but how many hours his machine works, as well. If the man works 10 hours and the machine only 6 hours, something is wrong. It probably means that an investment in apparatus and fixtures for handling and setting up would be profitable.

THE LE BLOND AUTOMATIC INDEX-PLATE DRILLING MACHINE.

The interesting machine illustrated in the half-tone, Fig. 1, and shown in detail in the line cuts, Figs. 2, 3, 4 and 5, is an automatic index-plate drilling machine, designed and constructed in the shops of the R. K. Le Blond Machine Tool Company, Cincinnati, Ohio, for their own use. As is naturally inferred from the name, the machine is employed for drilling the concentric rows of holes in the index-plates supplied with dividing heads, such as are usually provided with the knee-type milling machines made by the company. This work the machine does automatically, only requiring the blank plates to be mounted on the work arbor, and removed when completely drilled. The holes are accurately spaced and drilled to the required depth, and the change from one concentric row to the next is effected without the aid of the operator. Moreover, the machine is not confined to any set combination of holes—any practicable combination required may be drilled by supplying the necessary master index-plates arranged in the order desired.

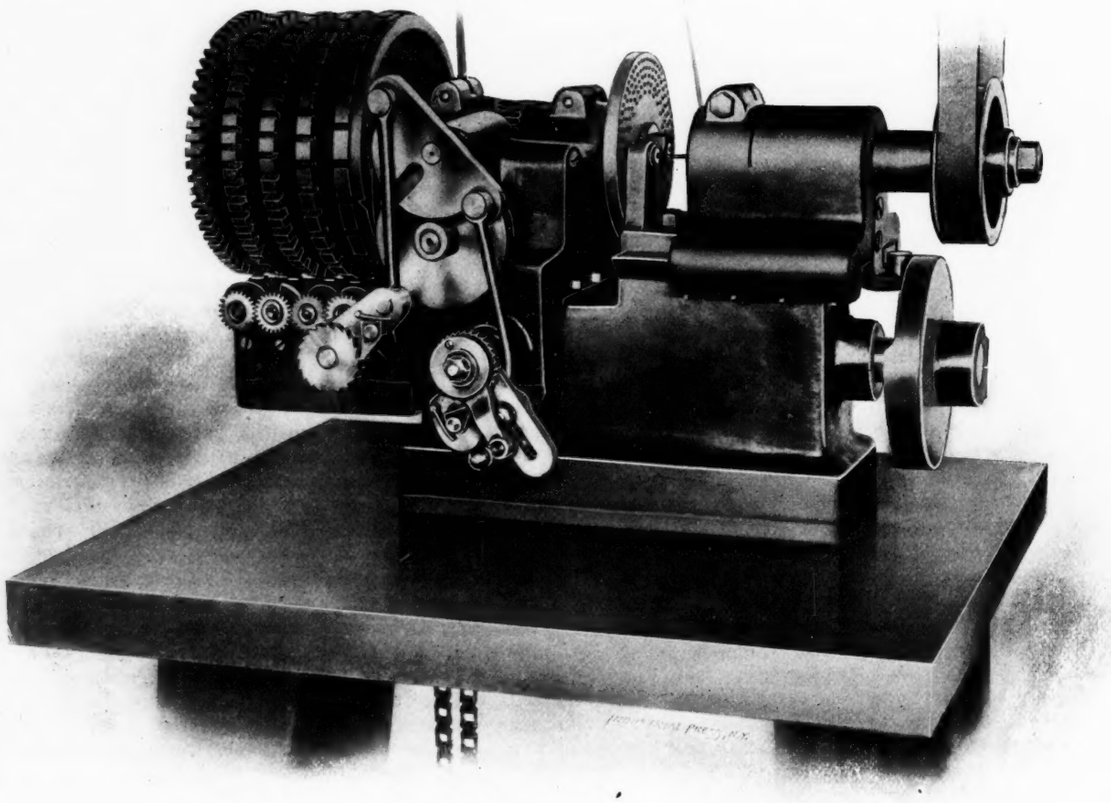


Fig. 1. Le Blond Automatic Index-plate Drilling Machine—shown large for detail.

The operation of the machine may be divided into five functions as follows: 1. Drilling the holes and feeding the drill. 2. Indexing for each concentric row of holes. 3. Rotating the blank as required for indexing. 4. Moving the blank transversely when one row of holes is completed. 5. Throwing the machine out of operation when plate is completed. Although rotating the blank is essentially part of the indexing function, it is complicated with another movement, and, for the sake of clearness, the two will be considered separately.

The drilling operation, of course, is simple, and it requires little explanation. The drill, ⅛-inch diameter, is mounted in the end of the drill spindle *L*, Fig. 2, without the use of a chuck, the end of the drill shank being tapered and fitted to the taper socket in the spindle. The spindle is independently driven at a speed of about 800 turns per minute. It is mounted in a sleeve or bushing which is longitudinally adjustable in the slide *V* to accommodate varying lengths of drills and compensate for wear. The feed movement of the slide V is effected by the disk *U* having a cam surface on its inner face which abuts against the friction roller *u*. The movement given the drill is ¼-inch, and its character is indicated in the development of the cam face at the bottom of the cut. The feed cam is mounted on the shaft *N* carrying the wormwheel *Q*, which is driven by the worm *W*. On the outer end of this worm shaft is mounted the driving pulley *Y*, Fig. 3. The slide *V* is retracted by the coil spring *v* indicated beneath it. The drill is guided by a hardened steel bushing mounted in a bracket attached to the base.

A master index wheel or plate is provided for each circle of holes drilled. These are indicated at *A*, A_1, A_2, A_3, and A_4, Fig. 2. Each master index wheel has as many notches cut in its periphery as are to be drilled in the corresponding row on the blank. These notches are milled so that one side is radial and the other tangent to a concentric circle about 2¼ inches diameter. Each wheel, of course, has an independent locking plunger, shown at *C*, C_1, C_2, C_3, and C_4. The plungers are forced into the notches by coiled springs, but all save one at a time, are restrained by the cams *B*, B_1, B_2, B_3, and B_4 from engaging the notches of the index plates. In the drawing the cam *B* is shown disposed so that the plunger *C* may engage the notches in the plate *A*. Each plunger has a rack milled out of its side, in which engage the pinions *E*, E_1, E_2, E_3, and E_4, all mounted on the common shaft *F*. Although the pinions are keyed on the shaft *F*, the shaft is free to turn within them through an arc of limited length, the keyways being made wider than the keys, as indicated in the section on the vertical plane *e-f*. Therefore when all the plungers are held down with their cams save one, say *C*, its pinion is the only one that receives the movement transmitted from the rack *G*. This movement occurs each time the master plate is to be moved one space, and is effected in a novel manner. The sprocket *H* carries a bicycle chain of forty links, hanging freely and filling no purpose except to carry the triangular block *h*. This block raises the plunger *G* as it rides over the sprocket wheel. The sprocket wheel has eight

teeth, so it makes five turns for one traverse of the chain, and since it makes fifteen turns per minute, it follows that the plate is indexed three times a minute. This, of course, agrees with the movement of the drill spindle slide *V*, making a total of 180 holes drilled per hour.

When one row of holes is drilled the indexing action is transferred from one master plate to the next. The cams *B*, B_1, etc., are mounted on the same shafts with the pinions *D*, D_1, D_2, D_3, and D_4, which are all meshed together and which receive motion periodically from the pinion *d*. When a row of holes is completed the shaft d_1, upon which *d* is mounted, is given one-fifth turn by means that will be described further on. The effect of this movement is to depress the plunger *C* and to release the plunger C_4. (This, however, is not the sequence; the action starts with C_4 and goes to the left and returns to C_4 when starting the next blank.) The plunger again springs into place in the next notch, and so on until the row is drilled.

Now we come to the action required for moving the blank transversely after one row of holes has been drilled. The work spindle and indexing mechanism is mounted on the slide *T*, having transverse movement on the base *S*. Partial rotation of the quadruple left-hand thread screw *j*, Fig. 3, produces the necessary movement. The genesis of this movement is the notch cut in the side of the master index plate A_4, Fig. 2, and shown in the view, Fig. 1. When the plate has made a complete turn the pin a_1, Fig. 2, shoots into the notch in the side of A_4. Its opposite end is engaged with a groove cut in the periphery of a_2, Fig. 3, and when the pin a_1 shoots into the notch in A_4 it releases a_2 and allows it to move to the right under the influence of the large coiled spring. This movement throws the clutch b_1 into engagement thereby,

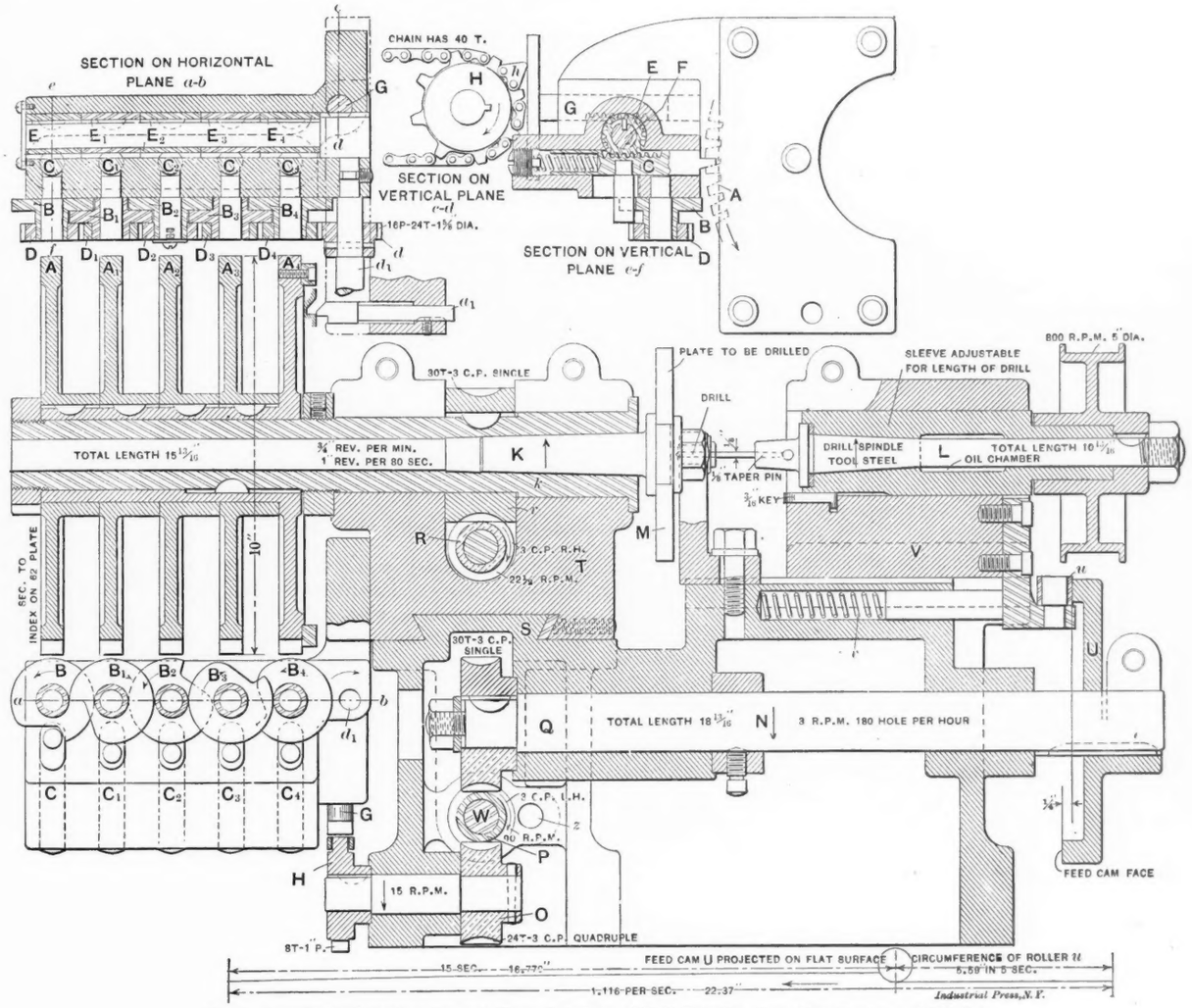


Fig. 2. Longitudinal Section through Work Spindle and Drill Spindle; also other Sections of Details.

master plate A_1 is made with a sleeve upon which the other master plates are mounted and keyed, and A_4 is keyed to the work spindle *K*. By this arrangement any desired combination of master plates may be assembled together and treated as one unit when a change is to be made, etc.

The work spindle *K* is driven by a worm *R* meshing in the wormwheel *r*. Referring to Fig. 3, it will be seen that the shaft o_1 carries the worm *R* and that the latter is extended to the left in the form of a sleeve, at the end of which is a friction clutch o_2. The gear *o* runs continuously, being driven by the pulley *Y* through the gears *m* and *n*; also the shaft o_1, on which it is keyed. But the worm *R* can turn only when the work spindle is released by the lowering of the locking plunger engaging the master plate. When the plate is released the frictional resistance of the clutch o_2 rotates the worm and turns the work spindle one space when the locking for the time being, locking the sleeve a_2 to the shaft o_1. The motion of the shaft is then transmitted to the disk *t*, which carries the pin t_1. This pin engages the slot in the double rocking lever t_2 and rocks it on its pivot, thereby transmitting a partial rotation to the shafts *O* and *j* through the connecting rods and ratchets *s* and s_1, Figs. 4 and 5. The left-hand ratchet s_1, operates the shaft d_1, carrying the pinion *d*, and the right-hand ratchet *s* moves the screw *j*, thereby giving the slide *T* the required transverse movement. The double rocking lever t_1 is mounted on the shaft *l*, which has pinion teeth cut on its inner end. These teeth engage a plunger *l*, abutting a coiled spring, the function of which is to return the rocking lever to its former position when released by the pin t_1. The action of *d*, it will be remembered, is necessary to change from one master index wheel to the next.

The disk *t* is stopped when it makes one turn by the plunger

a_1, which has been moved to its normal position by the passing of the notch in the side of A_4. The periphery of a_2 is cut with a groove, one side of which is inclined, as shown in the partial development at the right in Fig. 2. The end of the plunger a_1 rides along the inclined side of the groove and withdraws the clutch b_1 from engagement.

It will be noticed that a small coiled spring and a joint having a short end movement is shown in the shaft o, in the part adjacent to the pin a_1. The object of this, it is explained, is to provide clearance between the clutch teeth so that they will not rub and grate when disengaged. At the slow speed at which the shaft revolves there is not sufficient momentum to accomplish this as is done in other mechanisms of this kind having a high rotary speed. The clutch teeth are cut at an angle of 15 degrees, which angle opposes sufficient resistance to separation to compress the small coiled spring until the ends of the two shaft sections meet, when, of course, the cam, a_2, begins to pull the clutch faces apart. As soon as separation is effected the small spring pushes the outer shaft section with its clutch a short distance to the right so as to give ample clearance between the teeth.

The action somewhat incompletely described in the foregoing is repeated for each row of holes. When all have been drilled, further movement of the slide T brings the end of the screw Z into contact with the end of the plunger z. This plunger terminates at the left-hand end in a friction roller bearing against the side of the hub of the pulley Y. A spring (not shown) keeps the pulley in engagement with a clutch connecting it with the gear m. But the action of the plunger disengages the clutch when all the holes have been drilled, which stops the machine so far as the indexing, feed and transverse movements are concerned. The drill spindle, of course, continues to run, since it is independently driven by separate countershaft.

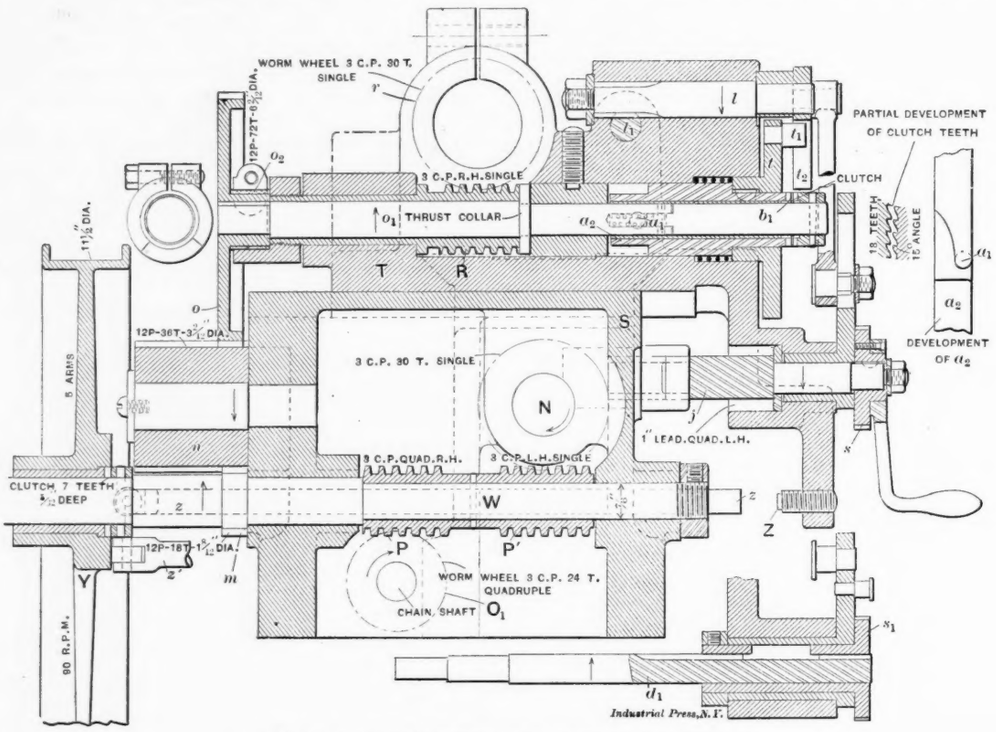


Fig. 3. Cross-section through Plane of Driving Gear, Etc.

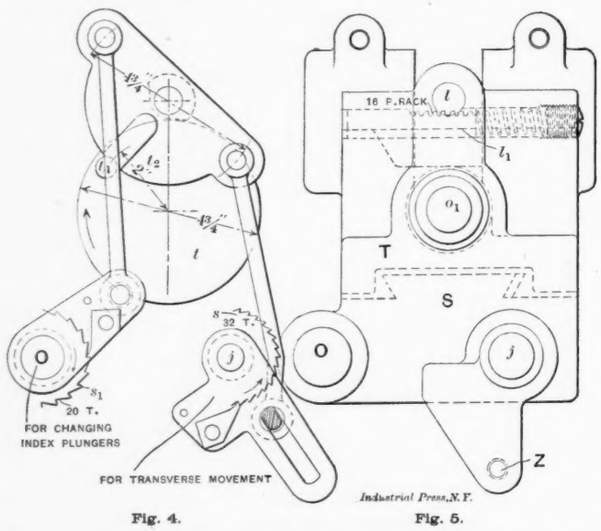


Fig. 4.

Fig. 5.

* * *

The Austrian government has recently made arrangements for an experimental motor service on the so-called secondary railroad which connects Trieste with the town of Buje in Istria. Experiments in this direction are also being made on a number of branch roads in lower Austria and Bohemia, and are being watched by the public with a great deal of interest. Local railroads in Austria have, generally speaking, been disappointments to both their owners and the patrons—to their owners because they are not profitable; to the public because their passenger service is insufficient. The railroad motor cars, which accommodate from 12 to 20 passengers, are expected to fill a long-felt want. They are comparatively light, carry no unnecessary incumbrances, and can be operated at a very small expense. They will make a number of regular trips daily, and as many extra trips as the exigencies of the traffic may demand.—Consular Report No. 1859.

* * *

During one day—January 18, 1904—the Manhattan Elevated Railway carried the enormous number of 1,025,000 passengers. This number is a record-breaker, the road never having before carried 1,000,000 passengers in one day. The increase of traffic is an indication of the growth of the city, but it is more indicative of the greatly increased capacity of the elevated system since electric power has been substituted for steam locomotives. For instance the steam-drawn trains consisted of five cars each and about the best the management could do was to give a service of forty trains at any one station per hour. With the electric service six-car trains may be run with a headway of only one minute, or sixty trains per hour.

HOW TO DRAW UP SPECIFICATIONS, ALSO TENDER, FOR MODEL ENGINE.

GEO. PLEYDELL PEARCE.

Some readers of MACHINERY undoubtedly earn a little extra money in the evenings in the way of model making. While this work is very remunerative to anyone who sets about it in a business way, many do it in a half-hearted and unbusiness-like style.

The most important thing when arranging to make any model for your customer, is to have a complete understanding from the very first, and this must be in writing, and state exactly what you contract to do. By starting the work on a good business basis you will save both time and money in settling disputes as to whether you contracted to do this, or that, or whether the customer actually told you to put on such and such a fitting, or only thought so, and the thousand and one other little things which crop up in a matter of this kind.

For the benefit of those who do not know how to draw up a complete specification, or tender, I have drawn a sample of each, in reference to a model compound engine, with boiler, but the same style and method can be used for anything of this nature, and if those interested grasp the idea they will find no difficulty in applying it to their particular case.

Specification.

For the construction of a small working model of a compound, non-condensing steam engine, with boiler, for Mr. ——, of —— Street, —— City, ——State, to the drawings of Mr. ——, of —— Street, —— City, —— State.

29-Oct.-'03.

General Conditions.

1. Definitions.—The term contractor used herein shall mean Mr. ——.

2 Generally.—The contractor shall make all patterns and obtain all castings necessary. The engine and boiler are to be constructed as a practical working model, and the contractor is to do all work necessary to make it so, even if such work is not specially referred to or described in this specification, or on the drawing.

3. Tests.—The boiler shall be tested by the contractor to a pressure of 80 pounds per square inch. The engine shall, before being painted, be tested with steam in the presence of Mr. —— and shall run at full speed for such time as Mr. —— desires, up to the limit of two hours. Any defects which may appear in the model at these tests, due to inferior workmanship, or materials, shall be made good by the contractor at his own expense.

4. Drawings.—The engine and boiler to be made accurately to the drawing, and as described in these specifications, and if any discrepancy should appear in the drawing, or in these specifications, the contractor shall inform Mr. ——, whose ruling thereon shall be binding and final.

5. Alterations and Extras.—No alteration or deviation to be made in the construction of the engine or boiler, as described in these specifications, unless Mr. —— shall consent or order in writing, and no extra will be allowed unless previously ordered by Mr. —— in writing.

6. Time of Completion.—The contractor is to complete and deliver the model in a neat box within ten weeks of the date of order, and if the contractor shall delay the completion (except by reasons over which he has no control, in which case Mr. —— may extend the time limit to such an extent as he may think fit) he shall pay or allow to Mr. —— as for agreed and liquidated damages, and not by way of penalty, the sum of $7.00 per week, for each and every week he may delay completion of the model beyond the stipulated time (or beyond the extended time limit, as the case may be).

7. Disputes.—In case of any disputes as to any matter arising under this contract, Mr. —— decision shall be final and binding on all concerned.

8. Payment.—Payment shall be made as follows: 33 1-3 per cent. on giving order, 33 1-3 per cent. on delivering model, in complete and perfect working order, and the remaining 33 1-3 per cent. in 7 days if the engine is found to answer all that was specified. If the engine does not answer requirements the remaining 33 1-3 per cent. will not be paid till the engine has been made as specified.

Construction.

Bed.—The bed is to be made of best cast iron, machined as shown on the drawing, and accurately fitted.

Cranks.—The cranks are to be made from a best machine steel forging in one piece, polished and machined all over to the dimensions given on drawing, the bearings and pins to be made within a limit allowance of + or — .0005 inch, the rest to+ or — .008 inch.

Connecting Rods.—The connecting rods are to be made of best machine steel, machined all over to dimensions given in the drawing with a limit allowance of .008 inch.

Cylinders.—The cylinders are to be of 2-inch and 3.25-inch × 3.5-inch stroke, made of best cast iron, and machined to dimensions given, with a limit allowance of + or — .0005 inch. The cylinder covers and valve covers are to be fitted with scraped joints, which are to be steam tight, without packing or paste of any description.

Valves.—And so on.

Everything is to be entered with full particulars, and the limits allowed for finished surfaces; also, which parts are to be painted, and what color; thickness of boiler plates; quality of material; boiler mountings, etc. These forms should be made out in full detail.

The following is the tender for the same model:

Tender.

Tender for making a model compound non-condensing steam engine, with boiler, for Mr. ——

SIR.—I hereby undertake and agree to make and deliver in a neat box, carriage paid, the model compound non-condensing steam engine, with boiler, described in the drawings and specifications prepared by Mr. —— and guarantee that it shall be made of best material, and in a thoroughly workmanlike manner to the satisfaction of Mr. ——; and further, I undertake that the engine, and boiler, shall be made in accordance with the conditions, and delivered within the time named in the specification.

Signature.....
Address..... Date.....
GEORGE PLEYDELL PEARCE, Philadelphia.

It is always advantageous in contract work to have a written agreement, and above all it is desirable to have an agreement that will "hold water." We therefore asked a competent lawyer to render an opinion upon the validity of a contract drawn in accordance with the above specifications, without attempting to criticise the phraseology from a legal standpoint. We believe that a mechanic would usually do better, in drawing up his own documents, to use very simple language and avoid the strictly legal phraseology. The opinion is given below.—EDITOR.

[The foregoing probably expresses with fair clearness the actual intentions of the parties—which is the most important quality in any contract.

The absence of a *price* would, of course, be supplied, in an actual "Tender."

It may be remarked that the provision in No. 7, "Disputes," giving one party to the agreement autocratic power to determine differences, is a contractual provision that courts are disposed to regard with extreme disfavor, and will not enforce if they can find a way to avoid it. It tends too much toward leaving one party in the position of having no agreement at all. It would be much preferable to name a third person, mutually agreeable, as arbitrator.

A friendly criticism may also be made of the statement in No. 6, "Time of Completion," as to delay on account of "reasons over which the contractor has no control." This provision might well open the door for dispute and litigation, as to what causes a delay were or were not within the control of the contractor. A personal encounter between the office cat and yard dog, in the vicinity of sand molds at an inopportune moment might well cause considerable delay, and be something over which the contractor had no control. Similarly, delays incident to over-celebration, by the workmen, of local elections etc., should not be a too convenient excuse for procrastination.

No doubt the writer's intention in No. 6 is to express the conventional exemption from "fire, flood or act of God." But the intention is rather too broadly expressed, and leaves loopholes for questionable grounds of delay.—W. E. WEAVER.]

Copyright, 1904, by the INDUSTRIAL PRESS.

Entered at the Post-Office in New York City as Second-class Matter.

MACHINERY

DESIGN—CONSTRUCTION—OPERATION.

PUBLISHED MONTHLY BY

THE INDUSTRIAL PRESS,

66-70 WEST BROADWAY, NEW YORK CITY.

CHICAGO—1462 Monadnock Block. BOSTON—620 Atlantic Ave.

LESTER G. FRENCH, Editor.
FRED E. ROGERS, Associate Editor.

The receipt of a subscription is acknowledged by sending the current issue. Remittances should be made to THE INDUSTRIAL PRESS, and not to the Editors. Money enclosed in letters is at the risk of the sender. Changes of address must reach us by the 15th to take effect on the following month; give old address as well as new. Single copies can be obtained through any newsdealer.

We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

MARCH, 1904.

NET CIRCULATION FOR FEBRUARY, 1904,—25,234 COPIES.

MACHINERY is published in three editions. The practical work of the shop is thoroughly covered in the Shop Edition—$1.00 a year, comprising more than 430 reading pages. The Engineering Edition—$2.00 a year—contains all the matter in the Shop Edition and about 250 pages a year of additional matter, which includes a complete review of mechanical literature, and forty-eight 6 x 9 data sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering, but is printed on thin paper for transmission abroad.

ALCOHOL FOR INDUSTRIAL PURPOSES.

In the May, 1903, number we published a review of the possibilities of the use of alcohol in the arts, with particular reference to what has been done abroad with alcohol motors, heating apparatus, etc. It was shown that while alcohol contains fewer heat units per pound than petroleum products, something like 30 per cent. of its energy can be utilized in an internal combustion engine as against some 15 or 20 per cent. of petroleum or gasoline. Other advantages of alcohol are that it does not have the disagreeable odor of gasoline, that it is nearly or quite non-explosive and that it can readily be produced from vegetable products, making it impossible to bring its manufacture under the control of a trust.

A bill is now before Congress providing that distilled spirits of alcohol may, when rendered unfit for drinking purposes or for use as a beverage, be moved from distillery warehouses free of tax, but under suitable government regulations; "provided"—to quote the words of the bill—"that sulphuric ether, wood alcohol, methylic alcohol, wood naphtha and other similar substances, shall be mixed with such distilled spirits as to render the same unfit for drinking purposes or for use as a beverage."

In Germany similar legislation was first enacted in 1879 and a committee appointed by Congress to investigate the use of alcohol in manufactures and the arts in Germany and elsewhere, show in a striking manner the advance made by Germany in the use of denaturized alcohol. Nine years ago 85,500,000 gallons were used for industrial purposes alone as against 10,000,000 in the United States. And taking into account the difference in the population of the two countries their consumption exceeded ours by 118,000,000 gallons. It is also pointed out that Germany uses in the arts nearly twice as much alcohol upon which a tax must be paid as of free denaturized alcohol—the latter being unsuited to many purposes.

In regard to the advisability of reducing the tax upon alcohol in America it is contended that it would make so slight a difference in the cost of small quantities used for beverages that there would be no increased consumption for this purpose and that it would lead to less "moonshining," which increases or decreases according to the amount of the tax. As to these latter contentions we have no desire to express an opinion but the experience of foreign countries where denaturized alcohol is used free of tax shows that it would be highly beneficial to the industries of the United States if alcohol so modified were available here under the same conditions.

* * *

IT PAYS TO KEEP INFORMED.

In a paper read before the Institution of Mechanical Engineers in England, upon Early English steam engines, it was mentioned that at the beginning of the last century a Newcomen atmospheric engine was built and erected some years after Watt had invented and applied the important improvement of the separate condenser. The Newcomen engine used a spray of water injected into the cylinder to condense the steam and required more than twice the amount of coal that was necessary to operate one of Watt's engines of the same power.

In the closing years of the eighteenth century news traveled slowly and it is quite conceivable that, even some years after an important improvement had been commercially demonstrated, a manufacturer might be ignorant of the fact. So it was that the invention of the separate condenser, which saved 50 per cent. of the fuel used under the boiler, was not known to the builder of the Newcomen engine—and his customer had to pay the bill for his ignorance.

Such lack of knowledge of mechanical progress is impossible at the present day, thanks to the various avenues for the dissemination of information. As a matter of course the daily papers touch upon the important mechanical events and so many people travel or conduct correspondence with those in widely different localities that no one is likely to be entirely ignorant of matters concerning his welfare, even though he make no particular effort to keep informed.

Nevertheless, every mechanic who is tied down to his work, so that he cannot keep in touch with people and events through personal contact or observation, must necessarily remain more or less in the dark, unless he make a reasonable effort to find out what people are doing, why they are doing it, and how they are doing it. The detailed information upon the progress of the mechanical work is regularly and faithfully presented in the columns of the technical journals and in the proceedings of the engineering societies and the best advice than can be given to any young mechanic is to avail himself of these opportunities, which the mechanic of long ago did not have, in so far as his time and means will allow. The information thus gained is one of the things that helps one to rise to a higher position. It is not altogether what a man can do with his hands that counts; it is what he knows, and what he can do with his brain as well.

Important as was the invention of the separate condenser it is paralleled by many of the great steps of progress of the present time, as a glance at the record for fifteen years will show. This period has been marked by the development of electric street railways; the general adoption of electric traveling cranes, which made heavy machine work possible; the use of high carbon steel forgings which made large engines and generators possible; the electrical transmission of power from immense water power plants; the introduction of gas engines of large size; the introduction and use of the steam turbine; the common use of the automobile; and in shop work have come the adoption of the floor plate system, with large portable tools; the introduction of pneumatic tools; a re-designing and strengthening of machine tools, with the invention of a great number of special tools; the extension of the automatic principle to machines of larger sizes; and now, with the high-speed steels at hand, there is every indication that there will be greater changes in machine tools than ever before.

These are only a few steps of progress, selected at random, that have come into prominence within fifteen years, and they are all vital to every ambitious mechanic. We contend that no mechanic can afford to let even a year slip by without taking some time each month and week to keep informed upon these things that are sure to affect his life and work in one way or another.

SUPERHEATED STEAM.

In another part of this number is an abstract of a paper by Prof. Storm Bull, of the University of Wisconsin, upon the use of superheated steam. Prof. Bull contends that we must adopt boilers with superheaters, and engines capable of using superheated steam, if we are to remain on a par with European practice. In explaining the advantage of superheated steam he states that the heat lost by the steam in an ordinary engine increases very rapidly with the adherence of moisture to the internal metallic surface of the cylinder. If that surface can be kept dry there is very marked decrease of condensation. With superheated steam there must, first of all, be considerable heat lost before there is any condensation and before any moisture is formed. In other words, superheat prevents initial condensation of the steam. He states that to obtain the best economy at least 200 degrees of superheat should be used, and this requires engine valves of special construction, such as poppet valves—those of the Corliss type being adapted only for superheat up to about 150 degrees. In answer to an inquiry as to whether changes were necessary in valves, fittings, etc., he says that it has been his experience that rubber gaskets of the best quality are highly suited to the purpose. He has had no trouble whatever with valves of the ordinary types.

In commenting upon the paper Mr. A. Sorge, Jr., who has had an opportunity to study conditions abroad, pointed out that the situation in Europe is considerably different from that in this country. There, labor is cheap and fuel expensive, while here labor is expensive and fuel cheap. He says that after talking with engineers abroad he found they had doubts as to whether, taking all the conditions into account—such as repairs, extra attention, necessary lubrication, etc.—the use of highly superheated steam was, after all, advantageous, although he did not wish to convey the opinion that he was not an advocate of superheated steam. He believed that in the end it would be of great value and economy, but was considering the situation as it now exists.

In reply Prof. Bull states that most plants constructed during the last five years in Germany use steam of at least 200 degrees superheat and the results with respect to lubrication and maintenance seem to be satisfactory. He also has had an opportunity to view conditions abroad and says that he has found that neither the question of repairs nor of extra labor is an important one. While repairs are necessary and the cost of installation is somewhat more, these will be small compared with the annual saving. He does not consider extra labor to be necessary in a superheated steam plant and believes that the low price of labor in Europe and its high price in this country has little to do with the adoption of superheaters in our power plants.

In the matter of fuel it would not pay to install a superheater next to a coal mine where, for instance, the coal cost $1 or less per ton but, just as in Europe in a great many places, so in this country, fuel is sufficiently expensive to make it pay to use superheated steam and the most economical engines. Superheaters, however, have been installed in Germany in the power plants of coal mines and have been highly satisfactory. With reference to lubrication these difficulties have been entirely overcome since the introduction of the heavy mineral oils which evaporate only at very high temperatures, and are well adapted to superheated steam engines.

It may be said in this connection that one of the best-planned and most attractive—although not among the largest—mechanical laboratories in this country is to be found in the University of Wisconsin, where Prof. Bull is located, and one of the pieces of apparatus is a compound steam engine, with poppet valves, built by the Nordberg Mfg. Co., Milwaukee, Wis. This has been subjected to test under superheated steam and affords an excellent opportunity for obtaining results under working conditions. A paper has been promised by the same author, at a later date, upon the use of superheated steam in connection with turbines, which we trust will contain as valuable information upon this subject as he has given us on superheated steam as applied to piston engines.

NOTES AND COMMENT.

Among the suggestions that have reached the editor's desk this month is the following from a designer of machinery. He says, "I have never had access to the methods of computing the cost of machinery and would suggest that articles on how to determine the cost of brickwork, stonework, steel buildings, cranes, machine tools, etc., would interest a large number of the readers of MACHINERY." The subject of estimating is one upon which very little has been published and we should be pleased to hear from readers experienced in this work, with a view to securing data for publication.

The editor of the *Mechanical Review* is very much incensed at an advertisement of the Pacific Coast Foundry, of Los Angeles, Cal., which appeared in the *Los Angeles Mining Review*. It is headed in bold black type "That English Pig," and goes on, "Is the best pig iron for making good machine castings, etc." The editor believes that such offensive advertisers deserve only the contempt of all decent business men. Evidently our English contemporary is not in sympathy with modern advertising dodges, but it nevertheless seems somewhat puerile to take offense at an advertisement which as a whole pays a fine compliment to an English product.

In a recent issue of the *Electrical Review* a seemingly innocent article was published, entitled: "Electricity in Siberia." The ubiquitous censors of the Czar must have taken a different view of the article, however, or rather of an illustration of a vertical steam engine that accompanied it. The cut was carefully blotted out leaving only the base exposed to view, but the descriptive matter was left untouched. It is hardly possible for us to fathom the workings of the Russian mind and we can only guess at the reason, but perhaps the intelligent censor imagined that an infernal machine or suggestion of one was hidden in the valve gear.

A curious contention has been raised in London with regard to the speed of automobiles. Under the present laws the highest speed at which an automobile can be driven within the city limits is 10 miles an hour and to emphasize what is held by automobile enthusiasts to be the absurdity of the law, four motormen of electric street cars were arrested and fined for exceeding this speed limit of 10 miles an hour. It is contended that if automobiles are restricted to 10 miles an hour trolley cars should be restricted to 7 miles an hour, for the reason that automobiles can not only stop within a much shorter distance but can steer clear of any danger, while an electric car has only one way of avoiding danger—that of using the brakes. This argument would be a good one were it not for the very fact mentioned, that a trolley cannot go around an obstacle, but must follow the tracks. It does not need to go around obstacles, because drivers of other vehicles knowing what part of the street it is to pass over get out of the way themselves.

Those inclined to superstitious beliefs have, we believe, quite unanimously associated the black cat with witchcraft and other occult trades, but we were scarcely prepared for the demonstration of destructive power emanating from a black cat's fur, alleged to have occurred in New York some time ago. It has been the custom to periodically "round up" all stray cats and dogs wandering about the city and put them to death in an iron box filled with gas. In shaking a large black tomcat from the basket into the lethal chamber it is believed that an electric spark was discharged from his fur; at any rate the "despatch" exploded with a flash and bang, causing disastrous results to the cats and bystanders. Three men were badly hurt, and the ceiling of the room is said to have been profusely decorated with cat remains in all states of dilapidation. If this cat story is based on fact it may explain some mysterious fires that have been caused by an unfortunate combination of cat fur—black or otherwise—and an explosive mixture of air and gas.

THE QUESTION OF POWER AT THE ST. LOUIS EXPOSITION.

There is widespread dissatisfaction among manufacturers who expected to exhibit machinery at the St. Louis Exposition, in regard to the recent decision of the directors to charge a flat rate of $10 per horse power per month for electric current. This charge is to be based on the rated capacities of the motors with which the various machines are equipped, without regard to the actual amount of power consumed, which we believe to be an injustice that must at once be apparent to those familiar with the practice followed in attaching motors to machine tools, woodworking and many other classes of machinery, that must be shown in operation to make their display effective.

Take the case of a machine tool builder who wishes to show several machines, any of which may be operated when it is desired to show their merits to a prospective customer. These machines may require from ¼ to 2 horse power at different speeds when running light and perhaps 1 or 2 horse power additional when they are at work cutting metal. Or if, as would be likely, the manufacturer wanted to be able to demonstrate the stiffness of his machines by using high-speed steel, still more power would be necessary upon occasion. Now this manufacturer might, if he chose, install a single 6- or 8-horsepower motor, connected up with a lineshaft and countershafts, and thus have to pay only for the rated power of this one motor, which would be sufficient to drive one or two machines at a time under all conditions. But that is not the way the tools would be equipped. At the present state of the art independent motors would be provided, each one of a capacity sufficient to operate its machine when performing the heaviest work that it would be called upon to do. The result would be that several motors averaging several horse power each would be required, and although not more than one or two would usually be running at the same time, and these usually much below their rated power, the exposition management would require this man to pay continuously during the time of the exposition for the aggregate power of the several motors—a sum that we know would be practically prohibitive to the average builder of machine tools.

This requirement is bad enough in itself; but coupled with it is apparently a complete reversal of the policy of the exposition officials, which has been sprung on the unsuspecting exhibitors at the eleventh hour. When manufacturers were solicited to take space in Machinery Hall, representatives of the exposition, as well as printed matter issued by its management, conveyed the impression that the charges for power would either be very slight, or else that there would be no charge at all—the latter being the understanding of many firms who arranged to take space. In fact, the printed blank supplied by the management, to be filled out by manufacturers in applying for space, contains the positive statement that "the director of exhibits and the director of works in their discretion are authorized to furnish gratuitously to exhibitors a limited amount of power for the operation of machines and processes." While under ordinary circumstances it would be expected that power would be charged for, the inference was so clear from the statements made that the St. Louis Exposition would be an exception in this respect, as to make the recent ruling a complete surprise and to cause vigorous protests from many concerns.

The matter was first brought to our notice by manufacturers in the machine tool field, who called attention to the features of the case which have been pointed out above. Inasmuch as it was our own understanding, also, that free power was to be supplied in any reasonable amount, we addressed a letter of inquiry to a list of machinery manufacturers whom we knew were intending to take space at St. Louis, asking for their experience in this connection and for an expression of their opinion. We also wrote Mr. Thomas M. Moore, chief of the Department of Machinery at St. Louis, whom we have always found willing to give courteous attention to everything pertaining to the interests of the exhibitors, citing what we had heard and what our own impressions were, and asking for a letter of explanation for publication.

Those written to have quite generally replied—some at considerable length. In a few cases no positive opinions were expressed, either because very little power would be required, and so the matter had not received attention, or from some similar cause. One machine tool builder said, simply, that he had no complaint to make, and three others that they had supposed in the beginning there would be a charge for power. These are the only ones heard from who intimate previous knowledge of this, and they do not state that their expectations were based on any specific information. We doubt that such information was actually given, because from what we can learn we believe it was the original intention to furnish a reasonable amount of power to exhibitors, gratis.

The balance of the letters are unanimous in their expressions of surprise and disapproval at the course now taken. The following comments from manufacturers prominent in the trade, and Mr. Moore's letter, while only part of those received, fairly represent the general sentiment and are so directly to the point as to make interesting reading:

COMMENTS BY MANUFACTURERS AND LETTER FROM MR. MOORE.

We were a little surprised at this request from the St. Louis managers, but are not interested in it at the present time as we have decided not to make an exhibit excepting in connection with some motor builders.

It was our understanding that power was to be furnished free until quite recently when we learned there was to be a charge made for same. We might also add that we have decided not to exhibit.

In our humble judgment, this exorbitant charge of $10 per month per horse power will be the cause of considerable friction between the exhibitors and the management. If we had made an exhibit, as we had intended, the cost to us for power would have been in the neighborhood of $1,500 for the six months.

The most objectionable feature, from our point of view, is that while we may see fit to install motors aggregating 15 horse power, our consumption of power is unlikely to average more than 4 or 5 horse power, but according to the published rates we must pay for a continual supply of current equaling the aggregate power shown by the name plates of all our motors.

We beg to state that there are plenty of kicks to be registered as to the charge for power at the St. Louis Exposition. We have not yet arranged for power and it is a question with us whether we shall arrange to run our machines at all at St. Louis. The Exposition is certainly not treating the manufacturers fairly in this matter and we are very glad to see you taking the matter up.

We were led, through printed matter or conversations, to think space and power would be free to exhibitors at the St. Louis Exposition, and we were not informed that a charge was to be made until we received yesterday from the exposition company their rules and regulations in which we see a very large charge for horse power is to be made, and it looks to us as if they were looking to make a large profit of 50 or 75 per cent. from this source. The result will be we shall use very little power.

We do not know much about the original offer to supply power free by the World's Fair at St. Louis. We do know that they now ask us $70 per horse power for seven months, with certain discounts for large quantities, varying from 10 per cent. to 28 per cent. Worse than this, they rate the power by the sum of the nominal power of all the motors used, although there may be but a few of them running all of the time, and these not anywhere near up to their full capacity. We are now trying to get the management to say that if we have a number of motors, one upon each machine exhibited, and run them only one at a time, leaving the others idle, we shall be charged for the rated horse power of the one running. We do not yet know how this matter will come out, but if as first mentioned the cost would seem to be prohibitive.

The following Letters assert that Positive Promises were Made with regard to the Charge for Power.

Our space at the St. Louis Exposition was applied for with the understanding that there would be no charge made for power or lighting. This was told us officially by one of the representatives of the Exposition who called upon us a year ago, and by referring to the "Rules and Regulations Governing Domestic Exhibitors," which formed a part of the application blank for space, in the item next below the middle of the second column, we read as follows:

"The director of exhibits and the director of works in their discretion, are authorized to furnish gratuitously to exhibitors a limited amount of power for the operation of machines and processes. The character of the exhibit requiring power for its operation will have much to do with determining the amount of power that will be furnished gratuitously."

In their pamphlet entitled "Division of Exhibits—Department of Manufacturers," Circular No. 1, on page 8, under this heading, "No Charge for Power," we read as follows:

"While reserving to themselves the right to charge for power, the administration is prepared to furnish it free when considered proper, as well as light and such other facilities as may seem reasonably necessary for the best presentation and operation of a desirable exhibition."

It was in view of the facts mentioned above that we applied for space at the St. Louis Exposition.

It is true that the earlier advertisements and announcements of the St. Louis Exposition proposed to furnish us power free of charge. It is also true that they now propose to charge us substantially, as you state, $10 per horse power per month. We recently discussed this proposition with the authorities at St. Louis and the only explanation they make is that the Exposition is assuming larger proportions and the expenses are running heavier than they had anticipated, and they felt it absolutely necessary to make this charge.

Candidly we believe the expenses of the exhibit as a whole will run about the same, or at least not a great deal in excess of other expositions; but it was, in our opinion, a great mistake on the part of the management to represent to exhibitors at the time of soliciting their co-operation that there would be no charge for power, and at this late date come in with an exorbitant charge, and we really believe it is going to have the effect of withdrawing some of the exhibits and curtailing very much in magnitude and appointment a great number of others.

We have had some correspondence with other manufacturers along this direct line, and they are all of them, in so far as we have any knowledge, feeling about the matter just as we are, only some of them stronger.

Our chief objection to the action of the exposition authorities is that they did not notify us until practically the last moment what the charges for power would be, or in fact, that there would be any charge at all; and that the literature first sent to us was such as to lead us to believe that light and power would be furnished free of charge. You probably have a copy of circular No. 1 issued by the Department of Machinery and by looking over this you will see that while no specific promise is given, it would lead one to believe that light and power would be supplied free of charge for such exhibits as require them for their proper display. The following quotation from this circular will probably make clear this point:

"The Louisiana Purchase Exposition proposes to depart from the usual practice of fairs and expositions and to make no charge for exhibit space and—within the discretion of the Director of Exhibits and the Chief of Department directly interested—to abolish charges for power, light and such facilities as may seem reasonably necessary for the best presentation and operation of a desirable exhibit."

Further, on page 10:

"There will be no charge for exhibit space, and none for power whenever the exhibit shall be deemed worthy of this concession, and motion is required for the proper illustration of the machine or process."

A Conservative Statement which Fairly Represents the Situation.

Our application for space was sent in about the middle of last summer, at which time nothing was said as to the charges to be made by the authorities. We wrote several times, asking what had been done with our application, but it was not until the first part of this year that we were definitely advised that space had been allotted to us, although we had been notified that our application would probably be favorably considered.

With this in view, we went ahead and got out several of the machines which we intended to exhibit and practically completed arrangements for installing our exhibit. After this had been done, we received a copy of the rules and regulations governing the light and power service, from which we find that the charges for power would be $10 per horse power per month, subject to certain discounts for the use of large quantities.

We also found about this time that it would be necessary for us to place the floor on our exhibit space, as none would be provided by the authorities. The expenses we had previously counted on, such as freight charges, cost of installation, attendance, maintenance, etc., would in themselves amount to a very considerable sum and when these other items were added, which we had not previously deemed necessary, the total was swelled to an amount which seemed to us to be entirely too large for the benefits that we could expect to receive and in consequence we gave up the whole idea of making an exhibit.

In other respects we have no fault to find with the treatment accorded us by the exposition authorities, but it does seem that they should have notified us at the outset as to the probable charges for power and any other expenses that might be reasonably considered necessary.

It may or may not have been a wise policy on the part of the exposition management to establish a charge for power in connection with the machine tool exhibit, which cannot be properly presented unless the machines are shown in operation, but we know that so far as we are concerned it resulted in keeping us out entirely; and we understand that it had the same effect on a number of other concerns.

The reply from Mr. Moore, chief of the Department of Machinery, with regard to the complaints of exhibitors, is as follows:

Explanation by Mr. Moore, Chief of the Department of Machinery.

You will observe from the copy of our Rules and Regulations regarding service of Power, etc., that there is a flat rate of $70 per horse power (or $10 per horse power per month) for electricity. This, however, is subject to quantity discounts which to large users will bring the cost down to $50 per horse power for the seven months' term of the Exposition. By roughly counting 200 ten-hour days as the term you will find the cost is 2½ cents per horse power hour. Such a rate, or even the maximum rate of about 3½ cents per horse power hour, surely cannot with justice be considered a grievance by any reasonable man. It is less than one-half of what the energy actually costs us, for we have all of our installation and dismantling expenses to average in the short run of seven months, and these expenses far exceed the cost of operation.

Those who complain of this rate should look up the rates charged at other great International Expositions. They should further remember that we have to install the machinery capable of delivering the maximum power which can be demanded of us at any one time. Consequently we cannot provide metered service, for on special days the demands on us would probably be ten times the average load and the daily load would only be on for a few hours. We cannot arrange for an intermittent service, that is for one exhibitor running certain hours and then shutting off in favor of another exhibitor, for when an exhibitor has a prospective customer he will demonstrate then, regardless of consequences to the Exposition or the other exhibitors.

With the growth of the Exposition it was found that if power were to be furnished gratis at least fifteen thousand horse power capacity must be furnished in addition to our already exceptionally large equipment, for to furnish power free to one practically meant furnishing it free to all. Further, it was not only a case of machinery equipment but of additional buildings to hold it and the time wherein to install it. The impossibility of such a situation became evident, so the Exposition practically divides the cost and charges exhibitors for current which is held available for their use at all open hours.

If exhibitors will study the situation carefully and intelligently they must admit this Exposition is conserving their interests and is most liberal in its provisions for their accommodation. There are no monopolies, no petty impositions; on the contrary the whole attitude and endeavor is to afford all a fair and abundant opportunity to join with the world in showing the progress of the world. The instances are very few wherein exhibitors cannot accomplish all reasonable demonstration at a very small expense of power. When the situation is investigated it usually results that whereas fifty horse power was estimated as the minimum of free power required, five horse power of purchased power will suffice for the real need of the same exhibitor. The case has yet to be discovered where our power charge has forced out or been really burdensome on an exhibitor. When sifted down to a fairly conservative and economical basis our power charge is relatively a mere bagatelle and not equal to 2½ per cent. on the average value of exhibits.

In our judgment Mr. Moore's letter does not meet the objections raised by exhibitors, so clearly presented in the letters which we publish. It will not satisfy the firms who were promised free power when they were solicited to take space and it will not make them feel that it is just to pay for several times the amount of power actually required at any one time, however reasonable the rate per horse power hour may be. These are the points at issue.

Mr. Moore's statement that it "is yet to be discovered where our power charge has forced out or has been really burdensome on an exhibitor" is far from correct, for we know that it has done both. In view of the avowed determination of the Department of Machinery to conduct their affairs on a broad and liberal basis, free from petty impositions, we trust they will find it expedient to reconsider their ruling in respect to the power charges, in the same broad and liberal spirit that has dominated their course in other directions. We believe it has always been their intention to work for the best interests of exhibitors, in so far as lay in their power.

A MILLING CUTTER WORKING ON A NEW PRINCIPLE.

In the September, 1903, issue announcement was made of the manufacture of a new line of heavy slab milling machines in the United States by the Hess Machine Co., Philadelphia, Pa. Not the least interesting feature of the new machine is the cutter which works on what is declared to be a distinctly new principle as applied to milling machines.

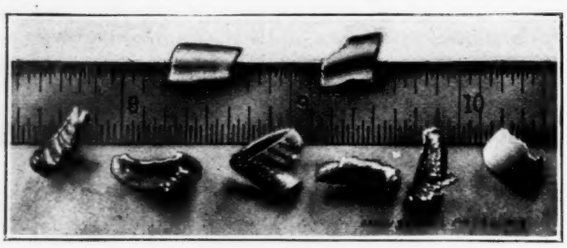


Fig. 1. Characteristic Chips Photographed Full Size.

The action of the ordinary milling cutter produces chips that are relatively wide and thin. Each successive tooth removes a chip having a length equal to the full width of the cut and of wedge-shaped section. The feed per revolution of the cutter is divided into as many chips as there are teeth in the cutter. Of course if the teeth are nicked the continuity of the chips is broken, but the action is substantially the same. Again, cutting the teeth on a spiral does not change the action materially; the most it does is to make the turning

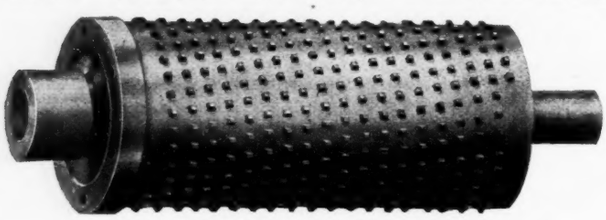


Fig. 2. Hess 15-inch Inserted-tooth Milling Cutter.

moment uniform and to preserve a constant upward thrust, which means a more even cut, freer from chatter marks than would be produced by a straight-toothed cutter under the same conditions.

One obnoxious result of the ordinary cutter action is the heavy thrust at right angles to the work; heavy as compared with the power required for the cut, and as compared with the upward thrust against the point of a roughing planer tool removing the same amount of metal per minute. So heavy is the upward thrust that it is scarcely possible to prevent quite perceptible deflection of the work downward and of the cutter upward when working heavy wide cuts. Even on the heavy type knee milling machines the deflection on heavy cuts is sufficient to make the cutter "hog" into the work perceptibly when passing from a broad to a narrow surface. One reason for the heavy upward thrust is that the common cutter working with the feed against the cut has a wedge action. The cut of each tooth is started on the thin edge of the wedge-shaped chip and the tendency is to slide over the metal instead of biting into it. This action is often quite noticeable, even with a sharp cutter, when first starting a thin surfacing chip over a broad surface. Now if a milling cutter could be made so that the chips produced were narrow transversely and thick vertically instead of long transversely and thin vertically the result undoubtedly would be a reduction of the upward thrust for the same amount of metal removed per unit of time. An imperfect illustration of the difference is that of a broad lathe tool taking a broad shallow chip, and a thin side-cutting tool taking a narrow deep cut. As anyone knows who has turned slender shafts the latter type of tool springs the work far less when removing the same amount of stock per minute.

The Hess milling cutter removes the metal in a series of narrow chips, the cut of each tooth being narrow and deep, similar to that of a planer roughing tool. A photograph showing some characteristic chips taken from tough steel locomotive rods is reproduced in Fig. 1. The chips were removed while working on the ends of two rods which made the total width of the cut 20 inches. The depth of the cut was 5-16

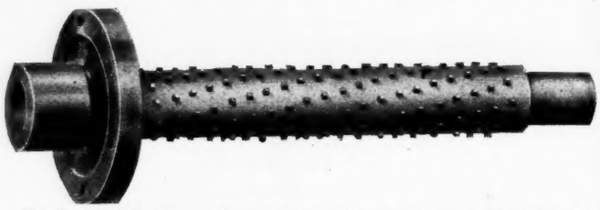


Fig. 3. Six-inch Cutter. Note Position of Teeth as Compared to Fig. 2.

inch and the rate of feed was 4 inches per minute, which makes the stock removed 25 cubic inches per minute.

The cutter is not mounted on a keyed mandrel as is the usual milling machine practice; instead, the outer end of the cutter body is formed into a journal supported by an outboard bearing, and the other end carries a large boss fitting into the end of the massive driving spindle. The end of the driving spindle is a flange 15 inches diameter and a corresponding flange is cast on the cutter. The two flanges are united by six bolts equally spaced on a circle 12¾ inches diameter thus applying the turning torque of the driving spindle at the end of a radius longer, usually, than that of the cutter. Figs. 2 and 3 show a 6-inch and a 15-inch cutter, the latter being the largest made, the diameter of the driving flange limiting the diameter of the cutter. The teeth are made of high-speed steel capable of working successfully at a cutting speed of 60 feet per minute. They are cast or fused into the cast-iron body by being placed into the mold and the metal poured around them.

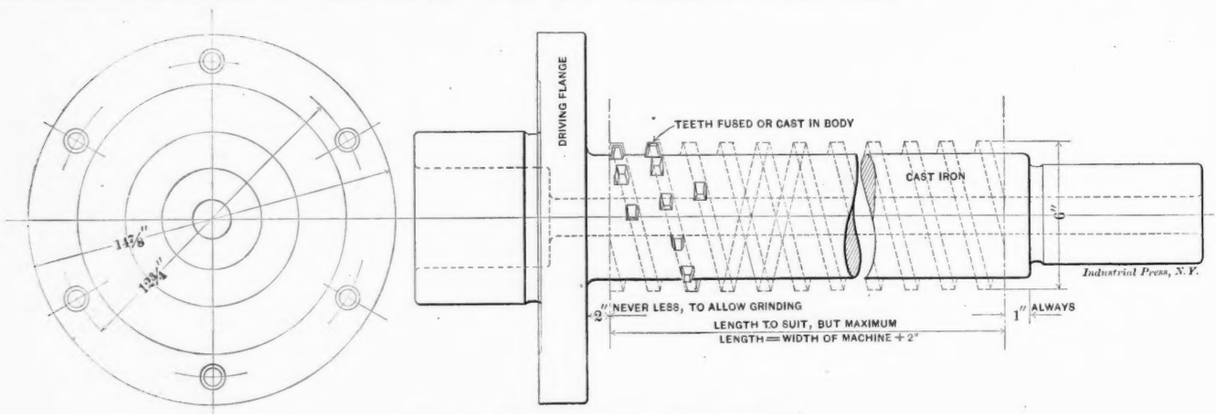


Fig. 4. Details of Hess Milling Cutter, 6-inch Size.

Fig. 4 is a cut made from the working drawing of a 6-inch cutter and shows, at the left, the boss which fits into one end of the driving spindle; the driving flange; the outboard journal at the right; and the characteristic arrangement of the rows of teeth. The teeth are usually arranged in a double right-hand helix having a lead of 3 inches. The pitch of the helices or threads of teeth is, therefore, 1½ inch. Since there are two rows or threads of teeth there are only two teeth in the same transverse plane and each tooth takes a

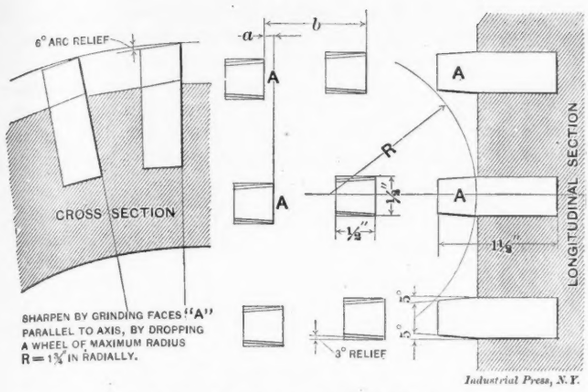


Fig. 5. Details of Teeth one-half Size.

cut whose thickness in the direction of feed is one-half the feed per revolution of the cutter. Since the paths of adjacent teeth overlap it gives each following tooth a smoothing action so far as its lapping portion is concerned. But the thickness of the chip taken by the lapping part of a tooth is thin as compared with the principal chip. The cutting action is very similar to that of a gang planer tool, each tooth having more of a side-cutting than of an end-cutting action. Consequently the thrust at right angles to the work is proportionately reduced. A severe test showing the absence of upward thrust was made while working on the locomotive rods referred to, the feed being stopped for five minutes while the cutter continued to revolve. During that time it sunk below the general surface only about .005 inch.

The teeth are reduced to one-half actual size in Fig. 5, which also shows the angles of relief, clearance, etc. The development of two threads of teeth (3 inches lead, 1½ inch pitch) of a 6-inch, 10-inch and a 15-inch cutter, one-eighth size, are given in Figs. 6, 7 and 8.

Modern competition has rendered it necessary to reduce the cost so far as possible in the shop. "High speed steel" furnishes a means of doing this on the lathe, planer and similar machines by making it possible to run at higher speeds, and use coarser feeds. When we use tools made from carbon or tempering steels it is not advisable to exceed certain speeds and feeds or the cutting tool becomes heated, and the temper is drawn to a degree that makes the cutting edge too soft to stand up to the work.

The high speed steels are not materially softened when heated by use in cutting, and consequently hold their edge when heated to a degree that would soften a carbon steel tool so it would be unfit for use until rehardened.

Not only is this form of steel recommended for tools used in removing quantities of stock at high speeds on the lathe and planer, but it is claimed that many times the amount of work can be done with such tools as milling machine cutters, taps, drills, dies, etc., if made from this steel over tools made from carbon steel.

In many cases that have come to the writer's notice it would seem that the parties advertising this steel were indiscreet in claiming as much as they do for tools made from it; had they claimed one-half the gain they advertise, the results would have been ample to warrant parties making the experiment. And many times tools have been made and machines sped up to the limit claimed, and when the tools gave out in a few minutes the party would condemn the steel. At first thought, the outlay of 60 to 80 cents a pound for steel did not appear out of proportion to the decreased cost of production, provided the tool did what was expected of it; but when it proved a failure then the cost of the steel, the increased cost of working it, and the time that Tom, Dick, Harry, and half a dozen others spent watching results were all taken into consideration, and as there was nothing to show in its favor it wouldn't have been a pleasant task for a representative of this form of steel to have happened in there to show his wares just then.

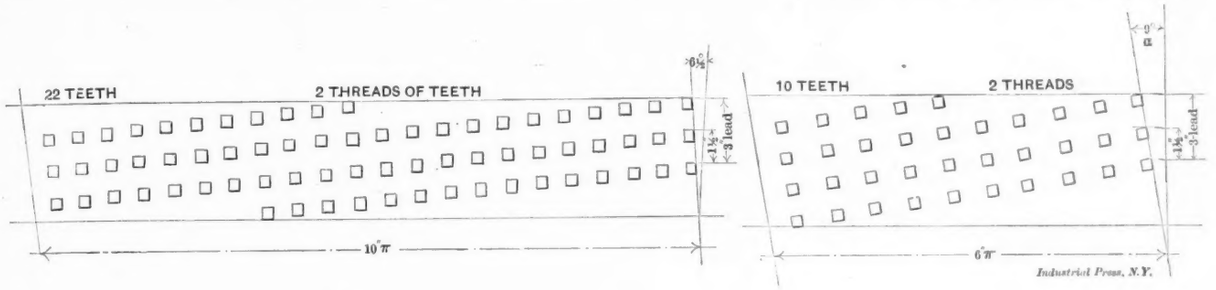


Fig. 6. Fig. 7.

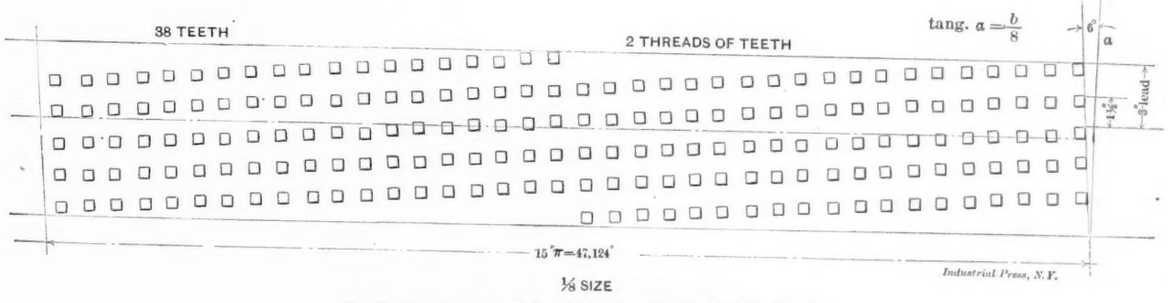


Fig. 8. Development of four Threads of Teeth, 15-inch Cutter.

HIGH SPEED STEEL.

E. R. MARKHAM.

There are very few progressive shops that have not tried the experiment of reducing the cost of removing stock from material being worked to shape in the machine shop, by means of the modern "high speed steels."

In many cases the results have proved all that could reasonably have been expected, in other cases the results have been anything but satisfactory to the party making the experiment, and as a consequence they have condemned the steel in no uncertain manner.

Now the advertising department of the house handling the steel may have been responsible in a measure for this. It is possible, and probable, that results equaling those claimed for the steel had been obtained when the tools were tried on dead soft stock, that was free from hard spots, etc.—the limit was obtained so far as speed was concerned. Now it is a fact that if you tell a man you will give him 10 per cent. more for his money than he can get anywhere else he is satisfied to buy of you and will advertise you and your goods to all his friends; but if you tell him you will give him 100 per cent. more and then he fails to realize this amount, he will

be very loud in his condemnation of you and your goods. Should he stop and analyze the matter he might find he was a gainer of 75 per cent. by the transaction, but no, he was promised 100 per cent. gain and he has been defrauded.

Now the above seems to be the case with quite a number of manufacturers who have bought high speed steels. They expected big things, but when they attempted to get the limit advertised for the steel and failed they immediately condemned the steel and everybody who had ever mentioned it to them. They did not try speeds and feeds a little less than those claimed possible, to ascertain if they could not make a very material gain over the records held by carbon steel tools, and if 100 per cent. was not possible, try and get 75 or even 50 per cent. or less gain, and considering that even at that they were well repaid for adopting the new steel for such work as it was adapted for.

Another reason why better results are not obtained in many cases is because instructions are not always followed implicitly when working the steel. The different makes of this steel are not all worked alike and the treatment necessary to give one make does not give best results when applied to another. For this reason the instructions given should be very carefully noted and followed as closely as possible.

Some steel houses, knowing that the experience of the ordinary tool dresser does not qualify him to properly forge and harden tools made from their steel, send men around to instruct the tool dresser in the art as applied to their brand. Now in order to get good results it is necessary to send out a good man, and even he finds difficulty in making the average blacksmith believe he can heat a piece of steel to a dazzling white and not spoil it.

A few concerns have made the mistake of sending out a man who knew little or nothing of blacksmithing. He didn't know how to make a fire as it should be made; and he handled the hammer like an amateur, and succeeded in impressing the blacksmith with the fact that he didn't know his business and that there was little to learn from him.

Experience has taught me that when tools made from this steel are properly forged, and heated for hardening, better results are obtained if the tool is held several inches from the mouth of the air blast when cooling, rather than close to the outlet.

A great deal depends on the shape of the tool. It may be forged and hardened in a satisfactory manner and then rendered unfit for use by improper grinding. I have seen tools which could not be made to stand up at all, but when reground and given the proper shape, worked all right.

Then again results anything but satisfactory are obtained at times because we are given to understand that we can run our work at so many feet per minute when cutting machinery steel. Now the term machinery steel, as generally understood among mechanics, covers everything between wrought iron and tool steel. A tool that would stand up when machining a very soft piece of stock at a high rate of speed would go right down if we attempted to use it on a piece that was harder if we run the work at the same rate of speed. It is not every mechanic who will discriminate between a low grade of steel containing 10 points carbon and one containing 60 points, yet in order to get tools to stand up well it will be found necessary to run much slower when machining the higher carbon.

I remember an instance where some milling machine cutters were made from one of the leading brands of this steel, and were run at 120 feet per minute on 70-point carbon open hearth steel. The results were not all that the party had been led to believe he would get. They would not stand up sufficiently long between grindings to warrant the extra expense of the cutters.

It was suggested that the speed be reduced very materially, and this seemed advisable for various reasons. When running at the rate of speed mentioned it was not possible for the operator to tend to the machine promptly, and the cutters were cutting air for some seconds at the end of each cut, and it was found that the machine, which was not built for any such business, was tearing itself to pieces.

The speed was reduced to 65 feet per minute, which was more than double the speed of cutters made from carbon steel when used on this work, and the cutters stood up well and proved a very satisfactory investment. Now had the manufacturing concern let the matter drop where the cutters failed to stand up when run at 120 feet per minute, and pronounced the steel a failure, and the men selling it humbugs, as many do, they would have failed to reap the benefits they are getting from its use.

This steel can be purchased annealed soft enough to work into tools of any form, or it may be annealed in the shop provided the necessary facilities are at hand. What we require is a furnace where we can get a heat sufficiently high and that we can keep for the desired length of time.

Various methods are recommended for annealing. Some claim good results by packing the steel in boxes or tubes with charcoal; others advocate lime, and still others claim sea sand gives best results; but the writer has had best results when the steel was packed in dry fire clay in a box or tube. He has tried all the others, but none of them gave as good results as fire clay. The boxes—or tubes—were placed in a furnace and heated to a yellow heat, and kept at this heat for a much longer period than when annealing carbon steel, the length of time depending on the size of the piece and the nature of the steel. When they had been subjected to heat for a sufficient length of time they were allowed to cool very slowly, the slower the better.

When machining this steel after annealing it is advisable to use tools made from the same kind of steel, as we can work more rapidly than if we used ordinary tool steel. If the instruction just given is followed it can be machined as rapidly as carbon steels when carbon steel tools are used.

In order to harden this steel satisfactorily it is necessary to heat it very hot. Instructions sent out with the steel say it is not possible to heat it too hot. This is not so; I have seen milling machine cutters which were heated so hot the teeth were melted off, but it is necessary to heat very hot, to a dazzling white heat, as it is termed. If we are hardening lathe, planer, or similar tools they should be cooled in a strong air blast of generous proportions. However, when hardening milling machine cutters, taps, etc., dip in a bath of oil.

The method of heating depends of course on the facilities furnished by the individual shop. Lathe, planer, and similar tools which are to be ground may be heated in an open fire, but milling machine cutters, taps, etc., must not be heated and then exposed to the air, or they will scale to an extent that would make them useless. In some shops they are heated in a crucible of lead, which is made very hot. It is necessary to use a graphite crucible or one made of materials that will not melt when subjected to the high heats. If the work is to be heated in the lead crucible, it must first be placed in fire and heated to a red before putting into the lead, as the sudden expansion caused by putting the cold steel into the lead heated to the high heats would cause it to crack.

A furnace burning gas or oil which can be heated to the required heat furnishes a more satisfactory means of heating work of this character than the lead crucible, as the pieces can be inclosed and so removed from the action of the air. When heated in the furnace mentioned better results are obtained, as the lead sticks to the steel. The high heat forms dross very rapidly, and this sticking interferes somewhat with the action of the oil on the heated steel.

The results that have been obtained in some shops with high speed steel are indeed wonderful, and there is no doubt but that the steel has come to stay until something is produced that is better.

The one thing necessary is that when working and using, be very careful to follow instructions implicitly except in the case of speeds which are not always to be taken literally, and I think were the parties who sell the steel to go over the ground again and make a list of speeds at which it is advisable to run the material, they would modify their figures very materially in certain cases.

So don't take it for granted that because, on certain work, you cannot get 200 per cent. more speed out of it than you have been getting from regular tool steel it is of no use; be satisfied if you make a 50 per cent. gain, provided you can get no more; that would well pay for the investment.

USE OF DIAGRAMS AND TABLES FOR THE SOLUTION OF PROBLEMS IN GEARING.

FRANK B. KLEINHANS.

It is no small task to figure out the proper strength for every gear in a train, and this is especially true when the entire arrangement of the train is a new one and the designer has no former construction on which to base the design. Let us take, for instance, the arrangement of the gearing in the design of a new 120-inch lathe or of a large-size planing machine. We know to start with, the required pull which is

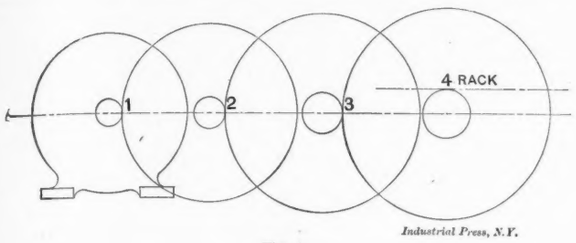


Fig. 1.

necessary on the outer circumference of the faceplate of the lathe, or we know the force that will be required at the tools on the planer. The diameters of the various gears have not been settled upon, and therefore we do not know the pitch line velocity or the pitch line force. We are accordingly obliged to lay down a train of gearing which our judgment leads us to believe will be satisfactory, and then figure out the velocity, pull, etc., and finally investigate the gears for strength.

This requires a great deal of time and patience, and frequently the results which are arrived at for a train of gears are of no account, and are therefore cast aside and forgotten. In this article it is intended to show a systematic method of calculating these trains and noting the results in the form of a table. This not only makes the work much easier, but reduces the liability to error and gives us a record of everything that has been done. We frequently find that a certain arrangement of gearing which has been considered unsatisfactory, and the results of which have been cast away, will work well, and, with certain alterations, is just what is wanted for another case. If we have these calculations noted in the form of a table we can refer to them at any time, not only during the design of the machine, but a long time after the machine has been built, for there are ever coming up questions in regard to alterations in design, in order to meet new requirements, and these calculations are then very useful.

Let us suppose that we have an arrangement of gearing to work out which would be satisfactory for traversing a head of a double-end boring machine. The head weighs 19,840 pounds and, allowing a pull of 25 per cent. of this amount to overcome the friction, we would require a pull of 4,960 pounds. It is intended to traverse the head at a speed of 25 feet per minute. We must know about what the frictional losses are in order to figure out the size of motor that will be necessary for doing the work. We find that, including friction, a little less than 7 horse power will be required to do the work. The nearest commercial size of motor that would answer would probably be one of 10 horse power, and we will assume that this is the size that we will use.

The motor and the arrangement of gearing with the proper reduction is shown in Fig. 1, the figures 1, 2, 3, etc., applying to the pair of wheels which are in contact at these places. In Table 1 we arrange the number of gears in the train, along the top line; then following on down the left-hand column, the number of revolutions of the pinion, velocity in feet per minute at the pitch line, the separate efficiency which applies to the pinion and its shaft, and then the logarithm of the

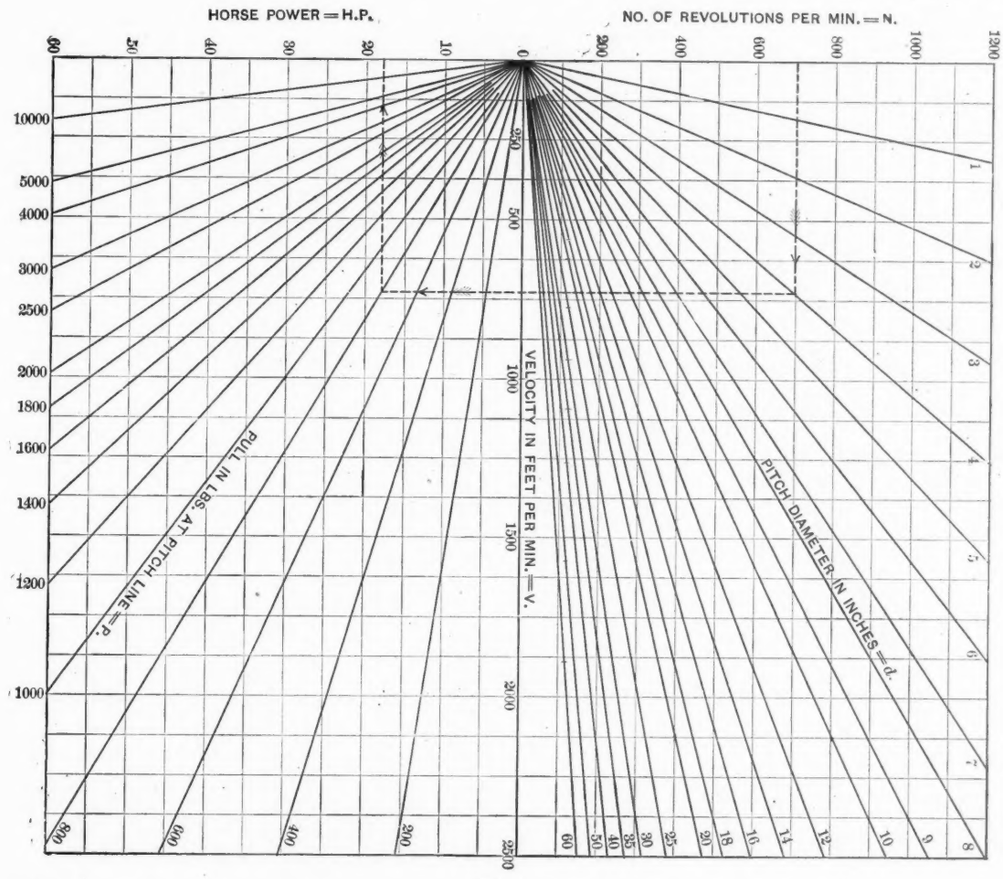


Fig. 2.

combined efficiency. From this logarithm we can obtain the necessary pull that will be required at the pitch line of the motor pinion in order to overcome the friction and perform the work. From these logarithms the pounds pull at the pitch line is obtained, and knowing this, and referring to our table for the strength of the gear teeth, we pick out a pinion with face to conform if possible with the patterns which we have on hand. A cast iron pinion having 20 teeth,

5 pitch and 2¼-inch face will stand an actual pull of 400 pounds, so all of these things are noted down in the table.

We then find in the next column for the gears marked 2, that the actual pull to suit the conditions of the pattern will be 930 pounds. The gear marked 3 will have a strength of 2,550 pounds; and gear 4 will have a strength of 11,000 pounds. Thus we can see by referring to the table just how much stronger the gears are than is actually required. Of course all of this calculation would be for the weakest member, which in this case will be the pinion. If we had a steel pinion engaging with a cast iron gear we would then have a set of figures for the pinion and another for the gears.

As all of the tables for the strength of gearing require us to know the velocity in feet per minute and the pull at the pitch line, the diagram shown in Fig. 2 has been arranged so that one can readily pick out any of the following specifications:

Number of revolutions.
Pitch diameter in inches.
Velocity in feet per minute.
Pull at the pitch line.
Horse power.

As an example, suppose we have a case where

$N = 700$ revolutions per minute.
$d = 4$ inches,
pull at pitch line $= 800$ pounds.

From the diagram we find that the motor required will be a little less than 18 horse power, as shown by the dotted line, and that for this case $V = 730$. We are thus able to pick out from the table without any calculation, the revolutions, diameter, velocity and actual pull as noted in Table 1.

TABLE I. CALCULATIONS OF GEAR TRAIN SHOWN IN FIG. 1.

No. of Wheel in Train.	1	2	3	4
Revolutions per minute	900	300	100	25
Diameters, inches	4 12	5 15	6 24	7
Velocity, feet per minute	940	390	160	45
Theoretical Pull in pounds	350	840	2100	7300
Separate Efficiency	.96	.95	.92	.80
Log. of Combined Efficiency	9.9823—10	9.9600—10	9.9238—10	9.8269—10
Pull in pounds required	365	920	2510	10900
Pull for which Gear is suited	400	930	2550	11000
Diametral Pitch	5	4	3	2
Teeth	20	20	18	14
Face, inches	2¼	2¾	4¼	4
Material	Cast iron	Cast iron	Cast iron	Forged steel

Let us take another case, shown in Fig. 3, where it is desired to use a motor in order to elevate the cross rail of a planer. The elements of the different parts are marked 1, 2 and 3, the latter being screws. We again arrange our table and in it note the numbers for the different parts of our

TABLE II. CALCULATIONS OF GEAR TRAIN SHOWN IN FIG. 3.

No. of Wheel in Train	1	2	3
Revolutions per minute	1200	400	240
Diameter, inches	4 12	4½ 7½	1¾
Velocity, feet per minute	1260	470	90 feet neutral line
Theoretical Pull in pounds	48	128	6000
Separate Efficiency	.97	.968	.408
Log. of Combined Efficiency	9.5834—10	9.5966—10	9.6107—10
Pull in pounds required	125	324	14700
Pull for which Gear is suited	150	500	Two 1¾" screws
Diametral Pitch	Chain	5	2
Teeth	"	22 37	Screw
Face	"	2	"
Material	"	Cast iron	Machine steel

train. The gears marked 2 are existing gears on the machine, as are also the screws 3. The cross rail weighs 6,000 pounds and is to be elevated at a speed of 12 feet per minute by means of the screw, which has a ½-inch pitch, double thread.

From the tables of Weisbach and Herman we find that the efficiency of a screw of this description is .408. The efficiency of train 1, from experiments under similar conditions, is known to be .97, and that of train 2 is .968. We then determine the horse power necessary for the work as follows:

$$H\ P = \frac{6{,}000 \times 12}{33{,}000 \times .384} = 5.68,$$

or, say 6 horse power.

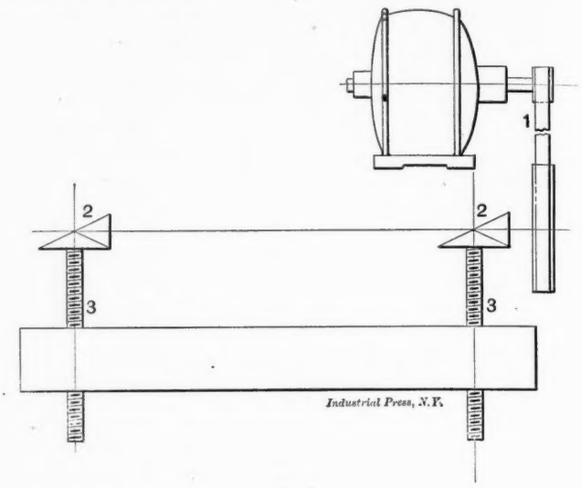


Fig. 3.

The velocity, pull, etc., are obtained from the chart and the gears picked out which will stand as much, or a little more than the required pull. One thing will be noticed in the last example: The actual pull is very much greater than the theoretical pull, and this is due to the enormous frictional losses in the screw. In taking up a new design we should sketch out the arrangement of the gearing and then arrange the data as shown in Tables 1 and 2.

* * *

SUPERHEATED STEAM.*

A REVIEW OF ITS DEVELOPMENT AND USE.

The use of superheated steam is not new; on the contrary, it is probably not far from 75 years old. The old masters in steam engineering, without doubt, realized the fact that the principal loss of efficiency in the steam engine was due to the condensation of steam in the cylinders, and, as is well known, they tried a great many means to reduce it, and with varying degrees of success. There is no question in the minds of all competent authorities that the best means of reducing the condensation is in the use of highly superheated steam, and this has been known for a great many years. It almost seems that the "grand old man," James Watt, anticipated or at least had a presentiment of nearly all the improvements in the steam engine which were to be introduced into its design during the last century. However, it appears he had no knowledge of superheated steam or of its advantages, which seems very natural, as he really was the first one who had an adequate and thorough knowledge of saturated steam. The first mention of the practical use of superheated steam which I have been able to discover, is found in the "Life of Richard Trevethick" of the Binner-Downs Mine in Cornwall, England. In this book it is stated that a certain Captain McGregor in 1828, in order to compete with a record established by an engine of a neighboring mine, whose cylinders had been insulated with sawdust, built a jacket of brick around the cylinder and the steam pipe, with an air space between the brick work and the iron and that he built a fire in this open space, by which means he increased the duty of his engine from 41,000,000 to 63,000,000 foot-pounds per bushel (86 pounds) of coal. Trevethick himself tested the 70-inch cylinder engine with steam at 48 pounds pressure and which made 8 strokes per minute, and he found that by using 5 bushels of coal in 24

* From paper by Prof. Storm Bull, Journal of the Western Society of Engineers December, 1903.

hours under the cylinder, he reduced the consumption of coal by the boiler from 108 to 67 bushels for the same work, showing a saving of more than 26 per cent. That such a saving must necessarily have aroused attention is evident; but it has been impossible for me to find any trace of it in the published records. In 1834 John Ericsson made some experiments with superheated steam, but no record of these experiments have been found. The next record that I have been able to find is that in 1845 Mr. Longridge made several experiments with superheated steam at low pressure, and in 1851, he was followed by Rafford in France who took out patents for a superheating plant.

From this time on, and lasting, perhaps, for 20 years, the interest in superheated steam was very active. Among the many engineers and scientists who contributed to the progress in this line should be mentioned especially Hirn, Isherwood and Faraday. The first named made a great many experiments in 1857, using steam of 55 pounds pressure and temperatures from 410 to 490 degrees Fahrenheit. The results of his accurate experiments showed an increase in the economy of the whole plant of from 20 to 27 per cent.

During the fifties and sixties, however, the principal use of superheated steam was found in the marine engine, and in the literature of the subject quite a number of tests of steamships with and without the use of superheated steam may be found. Penn showed an increase of economy of 20 per cent. for the steamer *Valletta* with a steam pressure of 20 pounds. The Parson and Pilgrim's superheater was especially designed for marine practice. It consisted of a number of semicircular pipes placed in the furnace, by which means it is stated that a saving of one-third in fuel was realized. The English Board of Trade, however, objected to the use of superheated steam on the ground that the high temperatures used were liable to break the steam up into its elements, thereby making it unnecessarily dangerous. Fortunately, Professor Faraday, who fully investigated the matter was able to convince the authorities that this objection was unfounded. The test of marine engines made at about the same time, during the latter part of the fifties, show gains in economy of from 20 to 30 per cent., always depending upon the amount of superheat which was available.

Our own Isherwood was at first very skeptical as to the practical use of superheated steam. He at first declared against it on the ground of injury to the cylinder, difficulty of lubrication, extra weight and short life on board of ship. Later on, however, he recommends the use of superheated steam because of the gain in economy of 30 per cent. shown by his experiments, but suggests that the limit of superheat be placed at 100 degrees Fahrenheit, on account of the difficulties of lubrication. In 1863-1864, he made extensive tests on the steamer *Eutaw* which had, a single, cylinder inclined engine with poppet valves and a Stevens adjustable cut-off. The best results of these tests show a gain in steam economy of 18 per cent. and 15 per cent. in coal consumption.

During the years from 1850 to 1870 a great many superheaters were installed, especially on shipboard, notwithstanding the fact that engineers always found great difficulties with respect to the lubrication and that the material of the superheaters did not withstand the action of the heat for a very long time. That there was trouble with the lubrication should not surprise anyone when it is remembered that none of our present-day mineral oils were known at the time, and that the only available lubricating materials were animal oils and fats. The steam pressure used up to that time did not exceed 50 pounds, at least not on shipboard, and for such a pressure the animal oils or tallow answered very well, even if the steam was superheated perhaps 100 degrees Fahrenheit. But the latter part of the sixties saw the introduction of the compound engine with its accompanying high pressure, and this proved to be a very effective damper to the use of superheated steam—and for two reasons. The first one was the very much greater economy of the compound engine as compared with the single expansion engine using steam of lower pressure, and because of this increased economy a saving of both space and weight, a very important factor in a ship. The second reason was that the difficulties in the way of proper lubrication of the cylinders became so great that it was found necessary to reduce the superheat to such an extent that the gain from it in economy became almost imaginary and this certainly did not warrant the expense of the installation of the superheater. The universal use of the compound engine on shipboard, therefore, very soon made the use of superheated steam impossible on steamships. It had been much less used in stationary practice, but with the gradually increasing pressure it also disappeared here. It is true enough that the use of mineral oils very soon after this time became general, but our present day heavy lubricating cylinder oils were not known then and in addition—and this is much more important—the attention of all the foremost engineers of the world, working in this line, was now exclusively directed toward the improvement of the economy of the steam engine by means of the use of higher pressure and of the compound principle; they lost sight of the superheated steam, presumably, because of the many bad reports regarding its use. You all are aware of the fact that the improvement of the economy of the steam engine during the last thirty years of the last century was all due to the increasingly higher steam pressure and to the introduction of the compound and multiple expansion engines, if exception be made concerning the greatly improved mechanical details, especially with respect to valve gear and governor. But toward the end of the last century nearly all competent engineers agreed that the improvement due to the causes just mentioned had about reached its limit. The increased cost of making more than a triple or quadruple engine was not warranted by the very slight increase in economy due to an additional cylinder—at least with the high steam pressure then practicable. Because of the available material it had been impracticable—perhaps unprofitable—to design boilers for a higher pressure than, say, 250 pounds. It is due to this fact that the attention of the engineering world has within the last half dozen years increasingly been directed to the use of superheated steam as a means of improving the still lamentably low economy of the steam engine, and it is my opinion that the history of these years has conclusively shown that for the present, at least, the outlook in this direction is very much brighter than in any other.

Recent Developments in Superheated Steam.

In recent years the development of apparatus for superheated steam has been more marked abroad than here and among its most prominent advocates have been Hirn, in Mulhouse, Schwoerer, his successor, and William Schmidt, in Germany, who was the first to use in practice highly superheated steam. You will doubtless remember the sensation that was created some eight years ago, when the results of tests on a boiler and engine constructed by William Schmidt were reported in the technical papers. Although the engine was quite a small one, yet it was shown that the consumption of steam was only about 10.4 pounds per indicated horse power per hour, when using superheated steam. The statement of the consumption by an engine of a certain number of pounds of superheated steam per horse power per hour does not give the means for a true comparison of the performance of this engine with one using saturated steam. It is much more equitable to base the comparison on the consumption of coal or the number of heat units converted into work. In the test spoken of it was shown that the amount of coal used per indicated horse power per hour was only about 1.3 pounds, certainly an extraordinary result for an engine of only 75 horse power. The engine in question was a tandem compound, both cylinders being single acting; of very original design throughout and built especially for the use of highly superheated steam. The boiler, which was also built and designed by Mr. Schmidt, was also very original and has since proved to be excellent in every way. As a result of this first test, Mr. Schmidt's engines became very popular and at the present time several hundred are running in Germany and adjacent countries.

As is well known there are two essentially different arrangements of the superheater with respect to the boiler. The most common is to install a coil in the boiler setting proper, through which the saturated steam taken from the top of the boiler is drawn on its way to the steam engine. If a high degree of superheat is wanted the coils must be installed in such a way that the hot gases will strike them long before they have been

cooled sufficiently to allow them to escape into the chimney. This arrangement has, as is well known, been extensively employed by the Babcock & Wilcox Company. On the other hand, if only a slight superheat is desired the coils may be placed so that the gases on their way from the boiler to the chimney will surround the coils. This last arrangement is usually not satisfactory, as the degree of superheat is so small that the gain in economy of the steam engine frequently does not warrant the installation of the superheater.

The second arrangement is to install an independent superheater with separate furnace, and a great many installations of this kind are found at present, especially on the continent of Europe. Many competent engineers have expressed their doubts as to the possibility of a gain in economy due to such installations, but repeated tests of a number of such plants have shown that these doubts were not warranted by the facts.

Both wrought iron or steel, and cast iron are used for superheaters. Because of the high temperature to which the material of the superheater will be raised, it is impracticable to have ordinary flange joints or couplings exposed to the hot gases. If therefore the superheater consists of a series of steel pipes of small diameter, they must be bent into coils, something like the ammonia pipes in a refrigerating machine. If on the other hand, the superheater is built of cast iron, there are usually a number of large, straight cast iron pipes connected by flanged return bends, the flanges being placed in such a manner that they cannot be reached by the hot gases, these pipes being also provided with a large number of external ribs so as to increase the heating surface.

The difficulties which were encountered years ago with respect to the wearing out of the superheaters have now been overcome, as can be readily seen from the fact that there are now in service superheaters which have been used continuously for eight years and without any important repairs. The number of plants now running in continental Europe is several thousand, of which several hundred are more than four years old.

It was also to be expected that the use of such high temperatures in the engine cylinder would create new difficulties, not alone with reference to the proper lubrication of the same, but also and perhaps still more so, with regard to the great expansion of the parts of the cylinder itself. But it can also be stated that all these difficulties have been overcome. Just as in the gas engine where the temperatures are very much higher, and where these difficulties have been overcome by the proper design of the cylinder, so in the steam engine our modern engineers have found the proper way to proportion the various parts of the cylinder in such a manner that the expansion due to the high temperature does neither produce breaks in the casting nor leaks at the stuffing boxes. With reference to the lubrication it is only necessary to refer to our modern heavy lubricating oils which made our modern gas engines possible. The latest type of engine designed for superheated steam does not look very different from an engine using saturated steam of very high pressure, although a good many details may be different. The experience of recent years is that Corliss valves are not adapted for the use of highly superheated steam and that consequently we will have to modify the design of our most economical engines in a very essential part before we can use with profit, steam superheated to a degree which will show an improvement in economy to a degree that will warrant its use.

TABLE I.

Size of Engine—12¼ in. x 27 7/16 in. x 19½ in.; vertical, tandem, compound, making—

	1st Test.	2d Test.
Pressure	156.2	159.0
Brake Horse Power	61.72	62.18
Superheat, Degrees Fahrenheit	235.0	281.0
Steam in Lbs., per I. H P., per hour	10.91	10.19
Steam in Lbs., per Brake H. P., per hour	12.61	12.34
Coal in Lbs., per I. H. P., per hour	1.36	1.26
Coal in Lbs., per Brake H. P., per hour.	1.57	1.52
Per Cent of Heat Accounted for in Saturated Steam	65.0	63.7
Per Cent. of Heat in the Superheat	6.9	8.2
Per Cent. of Heat given to Feed Water.	6.9	6.6
	78.38	78.5

In 1896 Professor Ripper of England published the result of a series of tests of a small Schmidt engine using superheated steam. The size of the engine was 7 1-16 by 11¾; it made 180 revolutions per minute. He used both saturated steam, and steam of different degrees of superheat in order to show the influence of the same.

TABLE II.

	1	2	3	4
Steam Pressure, Lbs. Absolute.	87.5	79.9	87 6	116.0
Temperature of Steam, Deg. F..	329.0	412.0	667 0	653.0
Degrees of Superheat, F	0.0	88.0	338.0	306.0
Indicated Horse Power	16.55	16.32	16.59	17.60
Lbs. of Steam per hour per Indicated Horse Power	39.33	34.66	19.13	17.58

It will be apparent from this table how rapidly the consumption of steam decreases with the increase of the superheat. With 338 degrees of superheat the number of pounds of steam used is not quite one-half that used for saturated steam. In itself this performance of a single-expansion, non-condensing engine, indicating only some 18 horse power and using less than 20 pounds of steam per horse power per hour is very startling.

A small Schmidt steam engine and boiler installed at Ascherleben, Germany, was tested by Professor Schroeter. The cylinder had a diameter of 9⅞ inches and a stroke of 15¾ inches and was single acting; it made 150 revolutions per minute. A series of tests was made to show the influence of the cut-off and of various degrees of superheat. The most important results were as follows:

TABLE III.

	1	2	3	4	5
Cut-off Per Cent	16.1	22.9	35.0	41.1	48.0
Steam Pressure, by Gage.	120.0	115.7	111.4	98.7	95.8
Temperature, Deg. F	669.0	671.0	673 0	680.0	689.0
Superheat, Deg. F	319.0	324.0	328.0	343.0	354.0
Consumption of Steam per Horse Power per hour	17.85	17.59	18.03	17.54	18.03

The results show that the cut-off has very much less influence on the economy of the steam engine when running with superheated steam than with saturated, because there is very little change in economy between a cut-off of 16 per cent. and one of 48 per cent., whereas it is probable that if the engine had been running with saturated steam this difference would probably have been at least 25 per cent. It is also well known that the interchange of heat between the steam and the cylinder walls is very rapidly reduced with increased superheat, so that, for instance, the heat absorbed by the walls during the admission period is almost zero when the steam is superheated from three to four hundred degrees. The gain in economy due to the use of superheated steam is not alone due to the greatly reduced condensation in the cylinder, but also and perhaps in just as high a degree, to the greatly reduced interchange of heat between the walls of the cylinder and the steam while it

TABLE IV.

Number of Test	1	2	3	4	5	6 (empty)	7	8	9	10	11	12	13	14	15	16
Indicated Horse Power Developed	316	277	222	170	118	22	318	272	223	170	121	226	227	223	223	218
Degrees of Superheat	.....	.....	.....	.....	.....	.....	204.4	225.2	225.9	223.9	223.9	43.7	97.7	151.7	221.2	310.9
Consumption of Steam in Pounds per H. P. Indicated	13.43	12.64	12.08	11.48	11.84	13.52	10.71	10.25	9.83	9.59	9.50	11.58	11.00	10.67	9.81	8.89
Gain in Economy on the Basis of Actual Consumption of Steam	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.04	.09	.12	.19	.26
Equivalent Consumption of Steam per H. P. Indicated	.....	.....	.....	.....	.....	.....	11.64	11.18	10.74	10.43	10.36	11.77	11.44	11.33	10.69	10.01
Gain in Economy due to Superheating, based upon Equivalent Consumption	.....	.....	.....	.....	.....	.....	.133	.121	.110	.104	.125	.024	.051	.060	.113	.174
Heat Units Required per I. H. P. per hour	278	261	250	241	245	280	241	231	222	216	214	244	237	234	221	207

Superheated Steam Engine Tests.

The principal results of the test of Prof. Schroeter of the Schmidt engine and boiler in 1895 and mentioned before, were as follows:

is in the superheated state, this being due to the absence of water, which is always adhering to the walls when saturated steam is being used. From a number of carefully conducted tests it has been shown that the steam at the end of the expansion in the high pressure cylinder of a compound engine is still slightly superheated, if the superheat to begin with is from 200 to 300 degrees Fahrenheit.

A month ago appeared a series of articles in the *Zeitschrift des Vereins Deutcher Ingenieure* by Prof. Schroeter, in which he gives the results of some remarkably interesting tests of a 250 horse power, compound steam engine, built and installed in Ghent, Belgium. The tests were made to determine the economy due to superheating the steam to various degrees and also to determine the influence of variation of load on the economy, using superheated steam. The results obtained from this engine are truly remarkable and in fact are so good that Prof. Schroeter says in the first article that the economy is higher than for any other engine of its size so far tested. A series of six tests with saturated steam and different loads was first made, then five tests with superheated steam, and for the same loads, with the exception of one, in which the engine was empty, and finally five tests were made for the same load but with different degrees of superheat.

The engine was a tandem compound, having poppet valves and ran-condensing. The cylinders were 12¾ inches and 22 inches in diameter, the stroke being 32½ inches, and it made 127 revolutions per minute. The steam pressure was kept as nearly as possible equal to 145 pounds by the gage during all the tests. The main results are given in Table IV.

By equivalent consumption of steam is meant the reduction of the number of pounds of superheated steam used to the equivalent number of pounds of saturated steam of the same pressure, the reduction being made on the basis of heat units contained. The comparison of economy on this basis is consequently, perfectly equitable. The results as will be seen, are certainly startling, as I do not know of any engine of this size which has as high an economy whether running with saturated or superheated steam, the best results being 11.48 pounds for saturated and 10.01 (equivalent) for superheated steam. It is also shown in the article mentioned that in several of the tests the steam was still superheated, both at the end of admission and of expansion, confirming the general statements in this respect made before in this paper.

* * *

LARGE FIRE PUMPING STATION FOR PHILADELPHIA.

The desirability of providing separate mains for domestic water supply and for fire service has long been evident to those interested in fire insurance matters. The existence of two systems of mains not only greatly diminishes the possibility of a failure of the water supply, but very often makes it possible to carry a pressure sufficient for fire protection without the need of fire engines. This is of special importance in crowded districts where fire engines are frequently subject to delay and often prove inadequate in fighting fire in modern high office buildings. While it would be possible to carry a high pressure in the regular service mains, it is entirely impracticable, not only because of the extra expense of pumping all the water at high pressure, but also the increased leakage and cost of fittings, loss of pressure, etc. Where a high pressure is maintained in separate fire mains, the individual fire protection systems of buildings may be so connected that water is always available on any floor of the tallest building.

However, it is not always advisable to maintain such a service from a municipal water-works plant, often because the distance through which it would be necessary to carry the high pressure mains would be unnecessarily great, and moreover an accident to the plant might disable both services. The high pressure pumping engine would probably be of a type different from the regular service engines, and little economy would be gained by placing them in the same station, further than a possible saving in attendance.

Many considerations favor locating the fire pumping station directly in the heart of the district to be protected. The character of the motive power then becomes the next consideration. If steam is used, it will be necessary to keep steam up in the boilers continuously, although the plant may be called into action only once or twice during a year. Electricity has also been proposed, and it might be advisable where connection could be had with a number of independent electric supply circuits, thus minimizing the chances of shut-down. One of the latest plants of this character has recently been completed in Philadelphia, where it is located on the Delaware River water front, at the corner of Race Street and Delaware Avenue. In place of electricity or steam, however, gas has been chosen for the motive power and Westinghouse gas engines have been installed, the fuel supply being taken from the city illuminating gas mains. The pumping station, which occupies a building 72 by 140 feet, will contain ten 11½ by 12-inch vertical, direct-acting Deane triplex pumps, each capable of delivering 1,200 gallons per minute at 40 revolutions, against a pressure of 300 pounds per square inch. There are also two 6¼ by 12-inch pumps of the same type of 350 gallons capacity per minute. These pumps are to work together or singly, as may be desired, and all will discharge into a common 20-inch main. The water supply for the pumps will be taken directly from the Delaware River through a 36-inch suction main. Only seven of the larger pumps are being installed at present. Each of the pumps will be driven by a separate engine. The smaller engines will be direct-connected to the smaller pumps through friction clutches and will also drive electric ignition generators of 7.5 kilowatts each and the air compressors supplying air at 200 pounds pressure for starting the main engines. There are three sources of current for ignition, connections with the city lighting mains and a storage battery being provided in addition to the ignition generators.

Triplex pumps have been selected because of the even flow of the discharge, producing practically constant pressure on the discharge mains and making a very even load through all parts of the gas-engine cycle. The crank shafts are driven from the engine shafts through single-reduction gears. The fact that the pumps are of the vertical type makes it very easy to connect the pumps directly to the engines and also results in a considerable saving in space.

Each pump is fitted with a by-pass valve and a relief valve, the manner of using these valves being well described in the following clause from the specifications:

"It is proposed to maintain about sixty (60) pounds pressure on the fire mains from the city reservoir. The pumps will be started under these conditions with the by-pass open, and any surplus of water pumped will be discharged through the relief valve into the suction main. When the engine is under way the by-pass will be closed and when the water is used as fast as this unit will deliver it, its relief valve will close. In the meantime a second unit will be started and handled in the same way and so on until the full plant is in operation."

The pressure in the fire mains is controlled automatically by an electric motor acting on a valve. It may be held steadily at any point under 300 pounds while a spring relief valve prevents it from rising above that amount. The water ends of pumps are divided into sections, that is, each cylinder and valve chest is a separate casting and can easily be removed by itself without disturbing the other parts of the machine. This makes a convenient arrangement in case repairs are ever required for the water-end parts. The machines were especially dsigned for fire service by the Deane Steam Pump Company, of Holyoke, Mass., and are brass fitted throughout in order that they may be able to start after long periods of idleness.

The mains supplied by this pumping station are nine miles long and consist of pipes of 8, 12 and 16 inches diameter. They are of extra thickness and all fittings, including fire plugs, are of special design. The station replaces with advantage more than 40 fire engines, and as a result of its installation the rate of insurance will be reduced 25 cents per $100.

The selection of gas engines for motive power is novel, but is believed to be justified in view of the perfection of the modern gas engine as regards reliability and freedom from break-down. The great advantage incident to the use of gas engines is their economy during periods of idleness, as compared with steam plants and the a,bility to start up immediately and at full power.

NOTES ON DESIGN.—1.

MACHINERY SHAFTING.

C. F. BLAKE.

At first thought it seems as if an article upon this subject should be prefaced with an apology. Undoubtedly shafting has been the subject of as much discussion as any thing mechanical, and the rules laid down for mill shafting are so well founded as to be available under all circumstances, and

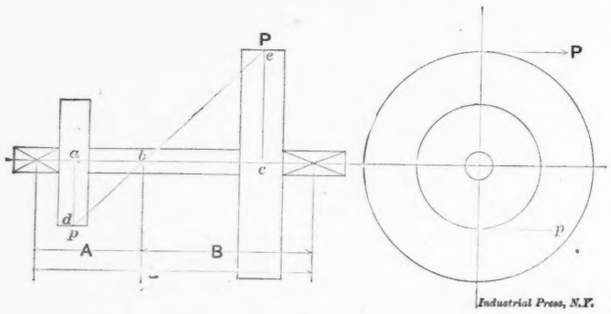


Fig. 1.

so widely known as to require no discussion. When it comes to machinery shafts, however, we have the ordinary rules for twisting and bending moments, and for the two combined, but we often find complicated combinations of loading needing investigation, and we find little or nothing in the text books about the present practice followed in fitting up machinery shafting.

In discussing the subject let us first take up briefly the three general principles governing shafting; simple twisting moments, simple bending moments, and combined twisting and bending moments.

When there is no bending moment the shaft may be designed for a simple twisting moment, and we have:

$$T = \frac{\pi}{16} d^3 f;\ d = \sqrt[3]{\frac{T}{.196\, f}} \quad \ldots\ldots\ldots (1)$$

in which T = the twisting moment in inch-pounds,
d = the diameter of the shaft,
f = the fiber stress in pounds per square inch.

Table 1 gives the value of $\frac{\pi}{16} d$ for different diameters of shaft, and $\frac{T}{f}$ = constant in table.

Example: A shaft is to sustain a twisting moment of 120,000 inch-pounds, the fiber stress being 16,000 pounds per square inch, required the diameter of the shaft.

$$\frac{120{,}000}{16{,}000} = 7.5$$

The nearest constant in the table *above* 7.5 is 7.55, the diameter corresponding to which is 3⅜ inches, which is the diameter of the required shaft.

A form of shafting frequently found in machinery is the stationary shaft, upon which certain heavy parts revolve, the shaft remaining stationary in the bearings, while the revolving pieces are usually brass bushed. Such shafts are often called pins, and being required to transmit no twisting moment, may be proportioned for a simple bending moment. Equating the bending moment to the moment of resistance for a round section we have,

$$M = \frac{\pi}{32} d^3 f = .098\, d^3 f$$

$$\frac{M}{f} = \frac{d^3}{10} \text{ very nearly.}$$

Table 2 gives values of $\frac{d^3}{10}$ for various diameters of shafts.

Example: A pin is to take a bending moment of 65,000 inch-pounds at 16,000 pounds per square inch fiber stress, required diameter of the pin.

$$\frac{65{,}000}{16{,}000} = 4.06$$

The nearest constant to 4.06 in the table is 4.06, the corresponding diameter being 3 7-16 inches.

When a revolving shaft through which power is transmitted, carries gears, drums or other devices, it is subject to both bending and twisting moments, and a calculation by either of the above tables ignoring the other will result in a weak shaft. We may, however, substitute for the simple twisting moment T a greater twisting moment T_e, which will be the equivalent of the combined twisting moment T, and bending moment M.

This equivalent twisting moment is

$$T_e = M + \sqrt{M^2 + T^2}$$

The diameter of shaft suitable for the combined moments T and M, may be found by substituting T_e for T in equation (1). This formula may be more conveniently used in the following form: Letting the ratio

$$\frac{M}{T} = k,$$

and letting,

$$D = nd,$$

where D = the diameter of shaft for combined moments T and M, d = the diameter of shaft for simple twisting moment T,

$$n = \sqrt[3]{k + \sqrt{k^2 + 1}} = \sqrt[3]{1.83\, k + 0.83} \text{ approximately.}$$

Table 3 gives values of n for various values of k.

d	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	d
1	.196	.237	.279	.331	.383	.446	.510	.586	.663	.752	.842	.945	1.05	1.18	1.29	1.43	1
2	1.57	1.72	1.88	2.05	2.23	2.44	2.63	2.85	3.07	3.31	3.55	3.81	4.08	4.37	4.66	4.98	2
3	5.30	5.63	5.99	6.36	6.74	7.14	7.55	7.98	8.42	8.88	9.35	9.80	10.35	10.88	11.42	11.99	3
4	12.57	13.17	13.78	14.42	15.07	15.70	16.44	17.66	17.89	18.66	19.43	20.23	21.04	21.89	22.75	23.64	4
5	24.54	25.48	26.43	27.42	28.41	29.45	30.49	31.58	32.67	34.76	34.95	36.14	37.33	38.57	39.82	41.11	5
6	42.41	43.76	45.12	46.53	47.94	49.40	50.87	52.39	53.92	55.50	57.09	58.74	60.39	62.09	63.80	65.57	6
7	67.35	69.18	71.02	72.92	74.82	76.79	78.76	80.79	82.83	84.94	87.05	89.22	91.40	93.64	95.89	98.19	7

Table 1. Values of $\frac{T}{f} = \frac{\pi}{16} d^3$

d	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	d
1	0.1	.119	.142	.167	.195	.222	.259	.297	.337	.381	.429	.480	.536	.595	.659	.745	1
2	0.8	.874	.959	1.04	1.14	1.23	1.34	1.45	1.56	1.68	1.80	1.94	2.08	2.22	2.37	2.57	2
3	2.7	2.86	3.05	3.24	3.43	3.63	3.84	4.06	4.28	4.52	4.76	5.01	5.27	5.54	5.12	6.17	3
4	6.4	6.69	7.02	7.34	7.67	8.02	8.37	8.73	9.11	9.49	9.89	11.29	10.72	11.14	11.58	12.15	4
5	12.5	12.95	13.46	13.95	14.47	14.98	15.53	16.07	16.63	17.20	17.79	18.39	19.01	19.63	20.27	21.09	5
6	21.6	22.25	22.97	23.68	24.41	25.14	25.91	26.67	27.46	28.25	29.07	29.90	30.75	31.61	32.49	33.61	6
7	34.3	35.19	36.17	37.12	38.1	39.09	40.11	41.13	42.18	43.24	44.33	45.42	46.55	47.67	48.84	50.30	7

Table 2. Values of $\frac{d^3}{10}$

Example: Suppose the shafts of the two previous examples are one, that is a shaft subjected to a twisting moment of 120,000 inch-pounds, and a bending moment of 65,000 inch-pounds, required the diameter of the shaft, with the fiber stress at 16,000 pounds per square inch as before.

$$k = \frac{65{,}000}{120{,}000} = 0.54$$

The corresponding value of n is 1.17.

k	n	k	n	k	n
.1	1.03	1.1	1.37	2.1	1.64
.2	1.06	1.2	1.40	2.2	1.66
.3	1.10	1.3	1.43	2.3	1.68
.4	1.13	1.4	1.46	2.4	1.71
.5	1.17	1.5	1.48	2.5	1.73
.6	1.20	1.6	1.51	2.6	1.75
.7	1.24	1.7	1.54	2.7	1.77
.8	1.27	1.8	1.56	2.8	1.79
.9	1.30	1.9	1.59	2.9	1.81
1.0	1 34	2.0	1.61	3.0	1.83

Table 3. Values of n for Various Values of k.

The diameter d for a twisting moment of 120,000 inch-pounds found in the first example is 3⅜ inches.

$D = 3.375 \times 1.17 = 3.94$ inches, say a 4-inch shaft.

A comparison of the three examples will show the importance of considering both the bending and twisting moments upon any shaft that is subject to both actions.

Another case of combined strains is shown in Fig. 2, where a gear under load P drives two pinions each under load p. First consider case A where all loads are in the same direction. Draw the bending moment diagram b-b-b for load P, also the diagram a-a-a-a for loads p. It is obvious, since the loads are on opposite sides of the bearing, that the bending moments will oppose each other, and the shaded portion of the diagram represents the algebraic sum of the two moment diagrams. Any ordinate of the shaded portion is the bending moment of the corresponding point of the shaft.

In case B the loads are not in the same direction. To find the moment at any given point on the shaft it is necessary to lay off separately, in the direction of each force, the bending moment ordinate for that force, as $MP = eb$, and $Mp = ba$, and take the resultant MR as the bending moment at the given point. This method may be extended to all forms of loading, as illustrated in the following examples:

Example: A shaft, Fig. 3, carrying a gear loaded to 2,140 pounds tooth load drives two pinions, each under 1,925 pounds tooth load, required the size of the shaft suitable for the given dimensions, the fiber stress being 9,000 pounds per square inch.

$T = 1{,}925 \times 3.6 = 6{,}930$ inch-pounds,

$Mp = 1{,}925 \times 4 = 7{,}700$ inch-pounds,

$$MP = \frac{2{,}140 \times 93 \times 4}{97} = 8{,}200 \text{ inch-pounds},$$

$MR = 11{,}248$ inch-pounds.

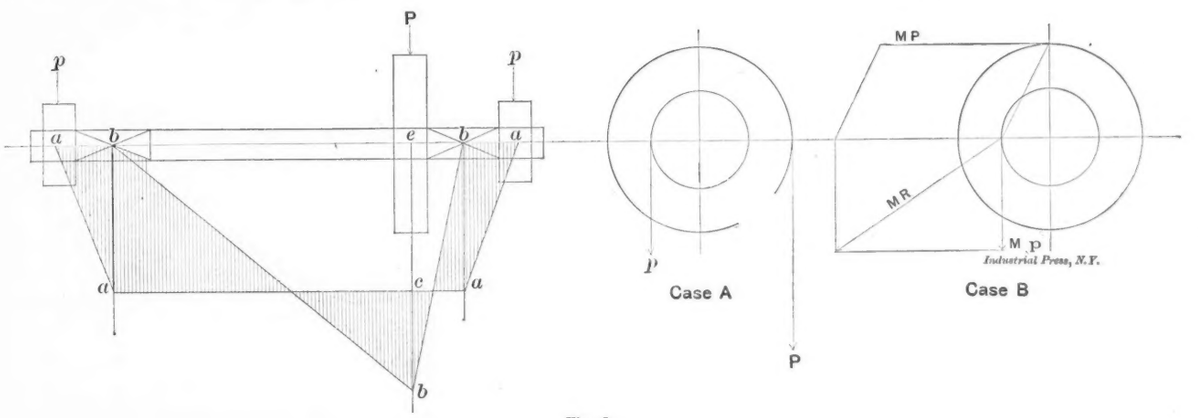


Fig. 2.

Gears, drums and other detail parts are so distributed upon shafting as to cause combined strains, and the maximum fiber stress resulting therefrom must be determined. A simple case is that of two gears between bearings, Fig. 1, the large and small gear respectively carrying loads P and p, the loads acting in the same direction. Connect P and p by a line cutting the axis at b.

Since the shaft must be in equilibrium, we have

$$p \times da = P \times ec,$$

$$\frac{p}{P} = \frac{ec}{da}$$

By the law of similar triangles,

$$\frac{ec}{da} = \frac{eb}{bd}$$

and substituting we have,

$$\frac{p}{P} = \frac{eb}{bd}$$

$$p \times bd = P \times eb.$$

The reaction at b is then $p + P = W$, and the bending moment is

$$M = \frac{W A B}{L}$$

The torsional moment is,

$$T = p \times da,$$

$$k = \frac{M}{T} = \frac{W A B}{L \times p \times ab} = \frac{(p+P) A B}{L \times p \times ab}$$

$$k = \frac{MR}{T} = \frac{11{,}248}{6{,}930} = 1.6,$$ the corresponding value of n being 1.51.

$$\frac{T}{f} = \frac{6{,}930}{9{,}000} = 0.77$$

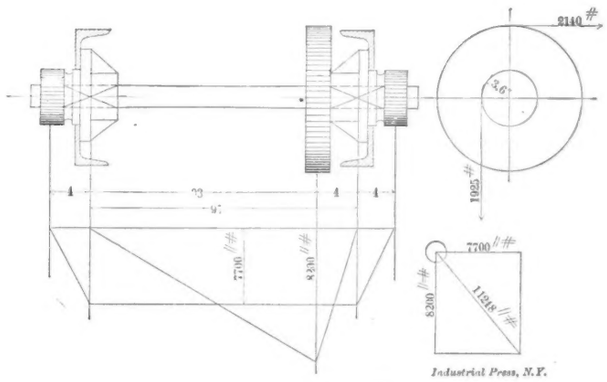


Fig. 3

From the table of values for twisting moments we find the nearest constant above 0.77 is 0.842 for a 1⅝-inch shaft. Then $1.625 \times 1.51 = 2.45$ inches for the required diameter of the shaft.

In all such cases as the above example, in which a shaft is supported upon channels or other unsymmetrical supports, the

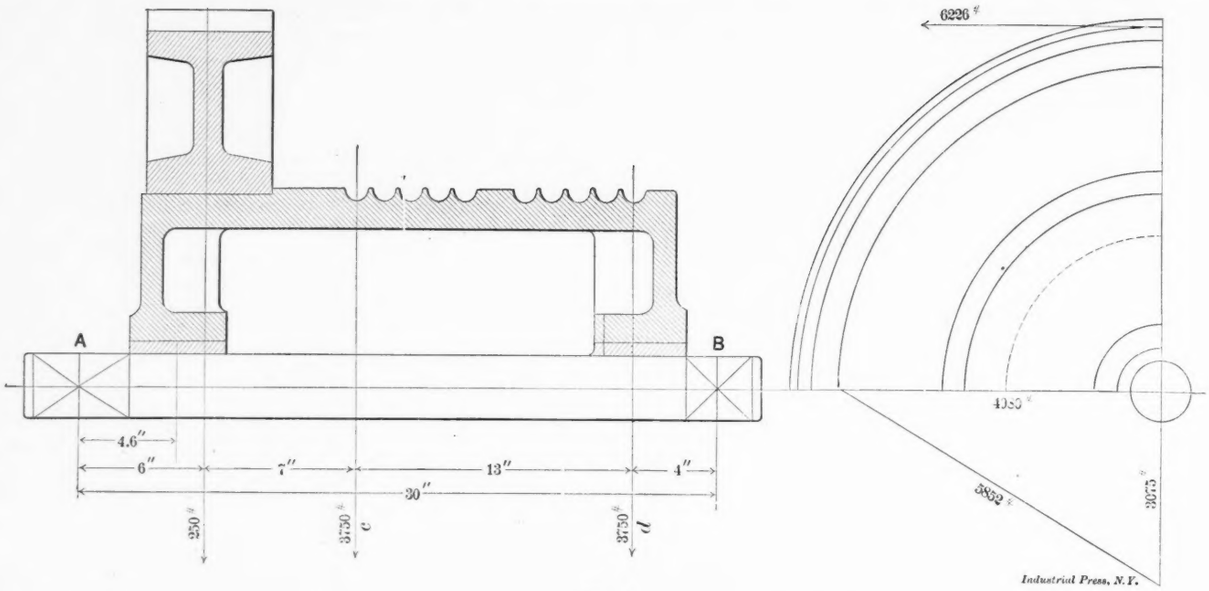


Fig. 4.

bending moment must be calculated to the center of gravity of the supporting member.

Example: In Fig. 4 we have a drum shaft of given dimensions and following conditions: Drum loose on shaft and bushed; weight of drum 500 pounds; two ropes leading from drum each under 3,750 pounds load; tooth load on drum gear horizontal; rope loads vertical; fiber stress to be 10,000 pounds per square inch. Resolving all loads to the heavier loaded journal we have,

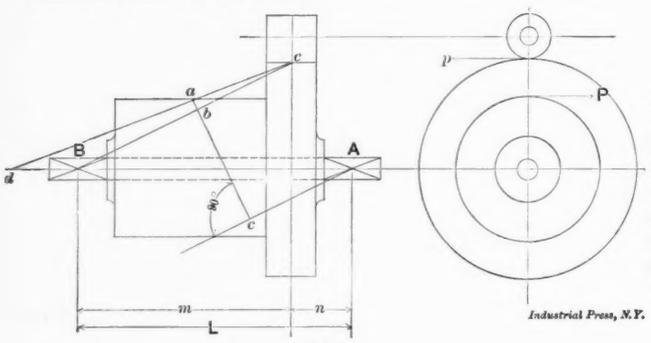


Fig. 5.

$\frac{6,226 \times 24}{30} = 4,980$ pounds horizontal load.

$\frac{3,750 \times 17}{30} = 2,125$ pounds, rope c.

$\frac{3,750 \times 4}{30} = 500$ pounds, rope d.

$\frac{250 \times 24}{30} = 200$ pounds, weight of gear.

$\frac{500}{2} = 250$ pounds, weight of drum.

total = 3,075 pounds vertical load.

The resultant of the horizontal and vertical loads on A is 5,852 pounds.

Then $M = 5,852 \times 4.6 = 26,919$ inch-pounds.

$$\frac{M}{f} = \frac{26,919}{10,000} = 2.69$$

In the table of values for simple bending moments, the nearest constant is 2.7 for a 3-inch shaft.

Fig. 5 shows a common arrangement of drum and gear, in which a is the center of gravity of the rope loads P. Where there are two ropes on the drum, the position of a is constant, while for one rope the position of a varies along the drum, and for the latter case several solutions should be made with varying positions of a. The load is supported upon three points, the journals A and B and the gear teeth at C. The load P puts a downward load upon each journal A and B, and is divided proportionally between them. In the figure a is central, so the loads upon A and B are equal, and are $\frac{P}{2}$; the upward load p at C is divided proportionally between A and B; thus we have

$$\left.\begin{aligned} \text{Load at } A &= \frac{C\,m}{L} \\ \text{Load at } B &= \frac{C\,n}{L} \end{aligned}\right\} \text{upward loads.}$$

loads at A and $B = \frac{P}{2}$, downward loads.

The algebraic sum of the two loads upon either journal gives the amount and direction of the resultant load on the journal. Draw $B\,C$ and Ca produced to cut $A\,B$ at d. We thus represent the load P as eccentrically supported upon a beam $B\,C$, at an arm ab, and prevented from rotating about $B\,C$ as an axis by the reaction of journal A acting at an arm bc. We thus have

$$\text{Load at } A = \frac{P \times a\,b}{b\,c} = W, \text{ upward load.}$$

$$\left.\begin{aligned} \text{Load at } C &= \frac{(P+W)\,B\,b}{B\,C} \\ \text{Load at } B &= \frac{(P+W)\,C\,b}{B\,C} \end{aligned}\right\} \text{downward loads.}$$

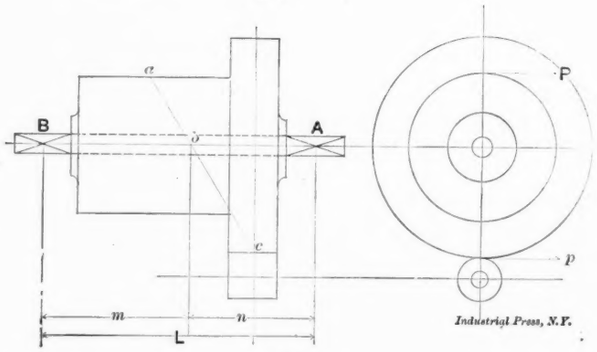


Fig. 6.

The condition of loading at journal A is seen from the position of point d, which lying beyond B as in the figure, indicates an upward load at A, lying on B indicates no load at A, and lying between A and B indicates a downward load at A, the weight of the drum and gear being neglected.

Fig. 6 shows the same arrangement with the pinion on the opposite side from a, and this case is analagous to that shown in Fig. 1.

COUNTERBALANCING LOCOMOTIVES.

G. E. LEE.

Every locomotive and railroad shop presumably has its own method of counterbalancing locomotive drivers and no doubt they prove generally satisfactory. The writer has used the following method with good results, and to make it is clear as possible an example has been taken which was used in actual experience.

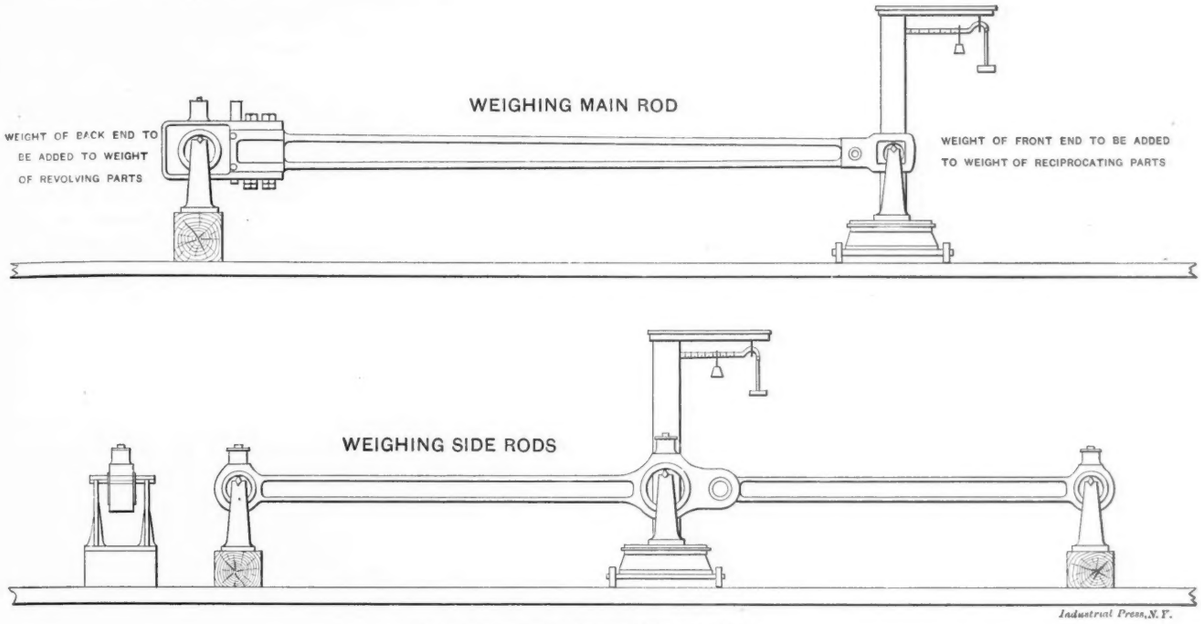

WEIGHING MAIN ROD
WEIGHT OF BACK END TO BE ADDED TO WEIGHT OF REVOLVING PARTS
WEIGHT OF FRONT END TO BE ADDED TO WEIGHT OF RECIPROCATING PARTS
WEIGHING SIDE RODS
Industrial Press, N.Y.

Fig. 1. Method of Weighing Main and Side Rods.

The accuracy of the method was tested by the wheels being pressed in place on the axles, crank-pins fitted and the whole mounted and leveled on horses where weights hung on the crank-pins until they balanced the weight of the counterbalance. These weights were found to be within a few pounds of the required weight; also when the engines were in service and running at a high rate of speed there was no indication that the wheels were out of balance. The accompanying forms and tables, Figs. 2 and 3, were used for keeping records. They are made on tracing cloth and printed on Vandyke solar paper, which is used as a negative for producing prints on ordinary blueprint paper, making blue lines on white ground. By filling in the weights a record can be kept and filed away.

Taking for our example a ten-wheel engine, weighing, in working order, 134,000 pounds, cylinders 19 x 24 inches, and using the form, all the figures are estimated from the drawing. But if the parts have previously been made, which, in this case, were all finished, the actual weights are taken. The side rods are coupled together and the weights for each pin taken as shown in Fig. 1. The rods are then uncoupled and weighed separately or all together. This serves as a check, as both totals should be equal. One-third of the main rod weight is considered in the reciprocating weights when the weight of the rod is estimated and the other two-thirds in the revolving weight. The crank-pins are estimated or weighed before being pressed into the wheels, and the weights of the crank-pin hubs and that portion of the counterbalance between the spokes are found in the following manner:

The driving wheel pattern is first made with the axle hub, rim and spokes finished to size and is then weighed. The crank-pin hub is then made and fitted into place and the wheel again weighed, the difference being the weight of the crank-pin hub, but from this weight must be taken the weight of that portion representing the crank-pin fit in the wheel. This is found by taking a block of the same material and turning it to the diameter of the crank-pin fit, and cutting it off to the length of the hub. The weight of this block taken from the above weight gives the required weight of the crank-pin hub in wood. Next take a block of wood, say, 3 x 5 x 8 inches (be sure this also is of the same material), which equals 120 cubic inches and weighs 1 pound 11 ounces, equal to 27 ounces, and find the actual weight in metal by using the factor for the material of the wheel which is .26 pound per cubic inch for cast iron. (See example in the column of notes on the form, Fig. 3.) The weight of the counterbalance between the spokes is found in the same way, the balance being made the thickness of the spokes, as shown by the sketch on the form, Fig. 3. Having found these weights we next find the total weight to be balanced.

We adopt the recommendation of the Master Mechanics' Association contained in their report of 1896 for the amount of the total weight of engine to be added to the revolving weights. We have, total weight of engine, 134,000 pounds, divided by 400 equals 335. This subtracted from the total

COUNTERBALANCE

REPORT FROM SHOP

WHEEL CARD NO._____ ENGINE NO._____ CLASS_____

NOTE:-
COLUMNS A & B FILLED IN BY DRAWING ROOM

		A	B	
RECIPROCATING WEIGHTS	ACTUAL WEIGHT	ESTIMATED WEIGHT	DIFFERENCE	REMARKS
PISTON & ROD COMPLETE	311			
CROSSHEAD & PIN "	226			
FRONT PART OF MAIN ROD	167			
TOTAL	704			

		A	B	
REVOLVING WEIGHTS	ACTUAL WEIGHT	ESTIMATED WEIGHT	DIFFERENCE	REMARKS
REAR PART OF MAIN ROD	333			
COUP. ROD ON MAIN PIN	275			
" " " INTER. "				
" " " FRONT "	126			
" " " BACK "	158			
CRANK PINS				
MAIN	160			
INTERMEDIATE				
FRONT	60			
BACK	69			

WEIGHTS TO BE HUNG ON CRANK PINS	MAIN		INTERMEDIATE		FRONT		BACK			
	731				267		267			
ACTUAL WEIGHT HUNG ON CRANK PIN	R	L	R	L	R	L	R	L	R	L
	700	740			273	277	280	270		
AVERAGE	720				Average	275				
DIFFERENCE	Light 11 Lbs.				Heavy	8 Lbs.				

Industrial Press, N.Y.

Fig. 2. Record of Shop Report

reciprocating weight and the difference divided by 3 (the number of wheels on one side), or 704 — 335 ÷ 3 = 123 pounds. The amount is the weight to be added to each pin. Now take the total weight to be balanced on the main pin, 1,090 pounds, multiply it by one-half of the stroke of the piston and divide the result by 17 (the distance in inches of the counterbalance center of gravity from the axle center). We find this to be 769½ pounds, which equals the weight wanted in the balance. Now referring to the form, Fig. 3, and in the column of notes we find the weight of the balance in iron between the spokes to be 453 pounds and the weight of the balance outside of the spokes is 312 pounds, giving a total of 453 + 312 = 765 pounds for the balance. This is 4½ pounds lighter than the estimated weight required.

COUNTERBALANCE

ESTIMATED IN DRAWING ROOM

COMPUTED BY,_____ CHECKED BY,_____

CLASS OF ENGINE,_____ ENGINE NO.,_____

WHEEL PATTERN,_____ CARD NO.,_____

MATERIAL OF WHEEL,_____ DIA. OF WHEEL,_____

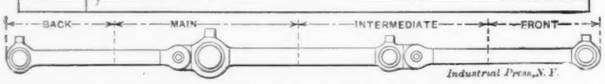
SKETCHES OF BALANCES

WEIGHTS							
PISTON & ROD COMPLETE	311	HUBS		CRANK PIN		RECIPROCATING WEIGHT	
CROSSHEAD & PIN "	226	MAIN	199	MAIN	160	PISTON & ROD COMPLETE	311
MAIN ROD "	500	INTER.		INTER.		CROSSHEAD & PIN "	226
INTER. " "		FRONT	133	FRONT	90	FT. PART OF MAIN ROD	167
FRONT " "	290	BACK	133	BACK	69		
BACK " "	251					TOTAL	704

REVOLVING WEIGHTS

NOTES		CRANK PINS			
	% OF RECIP WEIGHT TO BE	MAIN	INTER.	FRONT	BACK
Total weight of Engine 134000 Lbs.	ADDED TO EACH WHEEL	123		123	123
134000 − 400 = 335. 704 − 335 ÷ 3 = 123	REAR PART OF MAIN ROD	333			
Plate block 120 cu. ins. = 27 ozs.	MAIN SIDE ROD	275			
120X 26X16oz. ÷ 27oz = 13½ Factor for Iron	INTER. " "				
M. Crank Hub = 10 lbs. 12oz. = 172oz.	FRONT " "			158	
172X18½ − 16 = 138.8 say 139 lbs.	BACK " "				150
F. & B. Crank Hubs = 7 lb. 3oz. = 115 oz.					
115X18½ − 16 = 132.9 say 133 lbs.	CRANK PINS	160		60	69
M. Bal. between spokes = 24 lb. 8 oz.	HUBS	199		133	133
392 ozs. X 18½ − 16 = 453 lbs.	TOTAL WT TO BE BALANCED	1090		434	475
F. & B. Bal. between spokes = 14 lb. 1oz.	WEIGHT WANTED	769½		765 Average	
225 ozs. X 18½ − 16 = 210 lbs.	" OBTAINED	765		302	

BALANCE	CENTRE OF GRAVITY		HALF OF STROKE		WT. TO BE BALANCED		WEIGHT WANTED
MAIN	17"	—	12	X	1090	=	769½ Lbs.
INTER.		—		X		=	
FRONT		—		X		=	
BACK	16	—	12	X	1090	=	348.3 Lbs.



Industrial Press, N.Y.

Fig. 3. Record of Drawing Room Estimate.

Now referring to the weights returned from the shops, we find the average weight hung on each of the wheels as follows: On the main crank-pin it was 720 pounds, which, when compared with the revolving weights, *i. e.*, the sum of 123, 333 and 275 pounds = 731 pounds shows the balance to be 11 pounds light, but it is near enough for all practical purposes. The weights for the front and back wheels, being so nearly the same, their average was taken and the one pattern used for both. In the front and back wheels the balance is 8 pounds heavy, which makes a total of 16 pounds, and taking from that the amount the main balance is light, it leaves the combined balances 5 pounds heavy on one side.

If it is found that the balance cannot be made large enough to obtain the required weight, pockets must be cored in the balance and filled with lead. This will require a separate calculation, taking into account the difference between the weight of lead and iron, also the center of gravity of the pockets and balance.

* * *

The basis of estimating the size of hoist needed at a large mine is not, as might be thought, the amount of ore to be raised, but rather the hoisting and lowering of the men. In a large mine, where at the changing of shifts 100 men must be lowered and 100 men raised, it is important to effect the change as quickly as possible, otherwise in the aggregate a great deal of time will be lost.—*Mining Reporter.*

A WALKING LOCOMOTIVE.

In the April, 1903, issue an illustrated description was given of a novel traction engine called the "pedrail," which is the invention of Mr. B. J. Diplock. The pedrail is a "walking locomotive," being, as a recent consular report puts it, "a half traction engine and half walking machine." The machine is of grotesque appearance, but it seems capable of performing wonderful feats in negotiating bad and difficult roads—roads that, for any other traction vehicle, would be quite impossible and scarcely possible for those drawn by horses. It has been described as a traction engine which actually and literally walks upstairs with the stride and sure-footedness of an elephant and hauls loads behind it under circumstances that would bring an ordinary traction engine to a standstill. Ruts, curbstones and boulders it makes nothing of, and even 9-inch sticks of timber are as stubble before it.

"The pedrail indicates by its name that it is a rail carried upon feet. Instead of having a permanent rail carried for the whole of its length on permanent feet, viz., sleepers, and wheels running upon this rail, the process is inverted. The feet are (as in the case of the railway) placed upon the ground, but instead of the rails being carried upon the feet, these feet support wheels, and the wheels thus supported act as bearers for a short length of rail attached to the moving carriage. Briefly, the invention might be described as replacing the wheels of an ordinary traction engine by revolving frames carrying sliding spokes, each spoke having at its end a circular foot, and on the spoke itself, at a little distance above the foot, a small wheel or roller. In connection with each series of revolving spokes a fixed frame is attached to the side of the traction engine. This fixed frame somewhat resembles in form an inverted heart. When the axles revolve the spokes are carried round and in turn place the feet upon the ground. At the same time the wheels, which run round in contact with the heart-shaped frame, when brought underneath it—that is, under what may be described as the broader portion of the heart—act in turn as supports for the heart-shaped frame to glide over. Hence the engine is itself supported in turn through the wheels by the spokes which happen at the time to be resting with their feet upon the ground.

"The action of the pedrail on the road is very remarkable. Whereas the ordinary traction engines destroy roads to such an extent that they have been forbidden in many parts of this country and also in various parts of the world, and heavy motor wagons and traction engines have been severely taxed by local authorities and made to contribute to the repair of the roads, the pedrail positively improves the road over which it walks. This has been proved by actual experiment, and it is more than probable, from the remarks of an eminent municipal engineer, that the pedrail is destined to entirely replace the road roller for repairing roads, as the action of stamping or ramming is much better than rolling for this purpose."

* * *

One of the oldest weighing machine building concerns in the world, if not the oldest, is that of W. & T. Avery, Ltd., of Birmingham, England. Readers of MACHINERY will remember that in the November, 1902, issue a short history of this concern was given, in which the date of its founding is stated to be 1730. This old firm have a world-wide reputation and have always, it is said, been leaders in their specialty, which is weighing machines of all kinds from the heaviest track scales to the most delicate chemical balance. A recent interesting development in weighbridges made by the firm is one on which each car of a moving railway train can be weighed while traveling over it at the rate of about three miles per hour. As each car passes, its weight is indicated accurately on a dial without wavering or fluctuations, as would be expected from the nature of the conditions. This result is effected in part by the use of "lead-on" rails, which are short lengths of rails in the track having one end resting on a solid foundation and the other end upon the girders of the weighbridge. In this manner the weight comes upon the weighing levers gradually instead of being instantly transferred to same. The dial indicating mechanism is of a new type, in which the use of springs is done away with.

HIGH PRESSURE GAS DISTRIBUTION BY GAS POWER.

A gas power installation of exceptional interest is now under construction by the Laclede Gas Light Company, of St. Louis, Mo. The system has for its object more efficient distribution of gas over larger areas than may be economically covered by the simple method of running large low pressure mains from a centrally located gas generating plant to supply all parts of the city. The system under construction is intended to supply the entire city of St. Louis, embracing an area of approximately 65 square miles.

It is evident that in order to serve the outlying districts of such an area, one of three methods must be employed: 1st, large low pressure feeder from central holder to center of district to be covered; 2nd, medium sized feeders from main holder to auxiliary holder in center of district; and 3rd, high pressure feeder to distributing center, using pressure reducing valves at this point for obtaining proper pressure upon the service lines. The enormous expense for construction entailed by the first two methods has practically prohibited their use in St. Louis, and the high pressure system is being installed. With this system the size of feeder pipes is greatly reduced and the necessity of auxiliary district holders is entirely done away with.

For serving suburban communities, lying far beyond the city limits, this method may be extended and the pressure of the gas raised to any desirable extent for transmission through small pipes, this pressure being reduced at the suburban distributing center by pressure regulators, as in the medium pressure system above mentioned.

This gas distribution system as a whole presents a striking similarity to the ordinary alternating current distribution system with primary high pressure feeders, reducing transformers and secondary low pressure distributing lines, the theory of high pressure transmission being in both cases identical.

The pressures to be employed in the system under construction at St. Louis are approximately 5 pounds per square inch for the medium pressure feeders and from 20 to 80 pounds per square inch for the high pressure suburban feeders. On account of the use of cast iron mains, the 5-pound limit was chosen for the medium pressure system, but for the high pressure system iron pipe with screwed fittings will be used. With this construction any desirable pressure may be carried with entire safety and the radius of distribution extended to 100 miles if necessary.

In the medium pressure system, the gas pressure will be supplied by a blowing unit, consisting of a standard Connersville blower direct driven by a 300-horsepower Westinghouse, horizontal gas engine. The engine is of the type recently brought out for high power work and embodies a number of newly developed features which distinguish the construction of the horizontal type. The engine has two double acting cylinders, 16½ inches in diameter and 24 inches stroke, arranged in tandem with a single crank. The engine uses for fuel the ordinary illuminating gas such as is distributed to customers and draws its supply directly from the gas main. The engine operates upon the four-stroke cycle and the method of governing secures a constant quality of explosive mixture at all loads, the quantity of the mixture being proportioned by the governor to the load on the engine. Electric ignition is employed.

In this particular installation the engine is controlled by an automatic pressure governor which adjusts the speed of the unit in direct proportion to the demand for gas, the speed thus being in inverse proportion to the pressure in the distribution main. So sensitive is this control that the variation in pressure will not exceed eight ounces for a 50 per cent. range in gas output. The regular centrifugal speed governor is, however, also used in order to prevent, under any conditions, the engine running at excessive speed.

The St. Louis installation is one of the first of its kind in the illuminating gas field and presents many interesting features. The system has, however, long been in successful use in the distribution of natural gas over large districts adjacent to natural gas fields.

FRENCH TRACTION TRAIN FOR HIGHWAYS.

In Consular Report No. 1866 there appears a translation from a French journal briefly describing an "automobile railroad," which term, however, seems quite erroneous since the plan is one for coupling together road vehicles, each acting as its own tractor and traveling on ordinary roads having no rails at all. The description, nevertheless, is of considerable interest and relates to the road train designed by Col. Renard.

"This train is designed to transport passengers and merchandise at a moderate speed. Up to the present, automobilism has been, above all, synonymous of speed. Each manufacturer has bent his every effort to construct a type more rapid than his competitors. As to vehicles destined to carry heavy loads at slow speed, these have disappeared from the eyes of the public before the greater number of rapid carriages. If this means of transportation which responds to real needs has not been more fully developed, it is largely due to difficulties of a technical order. There are two ways of solving the problem—either to use isolated vehicles, or to hitch a locomotive tractor to a train of coaches or wagons. The first solution is evidently the more expensive, since it requires a motor for each vehicle and a motorman to conduct it, besides it only permits of transporting a relatively light load, unless the vehicles are made of weight and dimensions too great to be practical. As to road trains, they have encountered grave difficulties.

"In this train there is, so to speak, no hauling tractor. One of the carriages, the head one, is furnished with a motor —steam, gasoline or spirits—sufficiently powerful to draw the entire train at the desired speed. The power engendered by the motor is distributed to all of the vehicles of the train, and each one of them is provided with an arrangement by the aid of which the energy that is due to it is employed to work a pair of wheels, so that each carriage is a tractor to the same degree as the first, with the difference that the first is at the same time a "factor of energy."

"Each carriage works itself with the same facility as an isolated automobile. The adherence is therefore no longer due to the weight of the tractor, but to the weight of the entire train. One can thus make the tractor as light as an ordinary carriage and hitch it to as many carriages as desired without fearing the least sliding. The automobile at the head of the train, provided with a motor of 50 horse power, weighs only 1½ tons, and it suffices to furnish the necessary energy to draw a mixed train—passenger and merchandise—formed of seven or eight light vehicles, carrying a load of 10 tons, at the rate of about 12 miles an hour. The method of transmission of the energy from the motors to the diverse carriages is purely mechanical. It consists of a longitudinal shaft running from one end of the train to the other. The shaft is articulated in a manner to permit the train to negotiate curves.

"The parts uniting the different carriages are easily uncoupled to permit the separation or reunion of the carriages at will. Under each carriage there are gears which transmit the rotary movement of the shaft to an arrangement similar to that used in automobiles and working one pair of wheels. All of this obeys the manipulation of one motorman on the locomotive carriage at the head of the train. To conduct such a train involves no more difficulty than that of running an ordinary automobile.

* * *

Lead pipe, lead wire and similar lead productions are made by forcing the lead under heavy hydraulic pressure through perforated plates or dies. The containing vessel is first filled with melted lead, which is allowed to cool and solidify. In the manufacture of lead wire a pressure of about 40 tons per square inch is required to force the lead through the die. In the manufacture of lead pipe a mandrel is suspended in the chamber so as to project into the hole and stand concentrically within it. Electric cables are covered with a lead sheath in the same manner, the cable itself acting as the mandrel and being traversed through the container at the same rate as the formation of the sheath.

* * *

The National Machine Tool Builders' Association will hold their next convention in Cincinnati on Tuesday, April 26, 1904.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

It is reported that the United States Steel Corporation are installing the continuous rolling process in one of their Pittsburg plants. Although the process is not entirely automatic it requires fewer rollers, heaters and finishers so that the tonnage product per man will be practically more than doubled with no more exertion on their part than now. The question is how long will it be before the production of steel shapes from the ore will be almost entirely done by automatic machinery; it is rapidly approaching that condition already. One of the greatest changes in the industry has been the substitution of machinery for doing work that a few years ago required scores of toiling, sweating men, working under conditions often unbearable in the summer months.

In a paper read by Mr. N. Lilienberg before the Philadelphia Foundrymen's Association, on the history of steel plant construction, reference is made to the well-known fact that in 1856 Sir Henry Bessemer made the first steel produced by blowing air through pig iron. The priority was disputed some years ago by an American, but the claim does not seem to have been sustained. It has also been asserted that the process was in secret operation at Essen in Germany for some years before 1856, which, if true, shows the danger of conducting a manufacturing business on the trade-secret plan. The first steel converter was stationary, cylindrical, with radial side tuyeres near and parallel to the bottom. The pig metal was poured in through a hopper on the side. The flame escaped through a central hole in the top. Sir Henry Bessemer anticipated by patents many ideas which were afterward taken up by the others as original.

The B. F. Sturtevant Co., Boston, Mass., report that in the case of the Baltimore conflagration the old adage, "There is no great loss without some small gain," holds true; at least, to a limited extent. The salvage companies, who salvage goods damaged by fire and sell them for the benefit of the fire insurance companies, will profit by this loss. The goods damaged must be carefully dried before they become salable, and the Underwriters Salvage Co., of New York City, have placed an order with the Sturtevant Co. for the equipment of a kiln for drying such goods. The kiln is divided into small rooms of various widths served by overhead tracks from which are suspended frames for supporting two tiers of baskets for the reception of the water-soaked material. These rooms are of fireproof construction and the size is governed by the material to be dried. Hot air is diffused through the rooms while the amount of air and its temperature are easily controlled.

A suspended car ferry having a span of 393 feet is to be erected at Duluth, Minn. It is in effect a highly elevated bridge, the towers being 136 feet high, under which vessels freely pass, but the floor of the suspended car is only slightly elevated above the general street level. The motive power will be electricity, the motor operating wire cables attached to the trolley from which the framework and car are suspended. The car will carry a load of about 60 tons, which means that it can carry one street car, two or three teams, and altogether about 200 passengers. Its length will be 50 feet and the width 40 feet. It is pointed out that the suspended car ferry is superior to a drawbridge, as it practically does not interfere with navigation at all beyond that the vessels must avoid collision with the car, which, of course, is a duty devolving on both. The cost of the structure will be about $100,000. This is to be the first suspended car ferry built in this country.

A destructive explosion of two water-tube boilers in the power plant of the St. Louis Transit Company occurred December 21, 1903, in which seven men were killed and property damaged to the amount of $50,000. In view of the repeated assertions that a disastrous explosion of standard representative types of water-tube boilers is practically impossible, this disaster is interesting, inasmuch as the findings of the coroner's jury and the testimony taken indicate that it was caused by inadequate inspection and gross neglect, the immediate cause being thought to be over-pressure due to a stuck safety-valve. It was discovered after the explosion that some of the safety valves were so badly stuck that it is probable they would not have lifted with three or four times the rated pressure. The fact of the matter in regard to the operation of steam boilers is that no boiler is "safe" even with the most vigilant and unceasing care, but almost any type of well-built boiler is reasonably secure under competent supervision. That "eternal vigilance is the price of safety" in the boiler room there is no doubt.

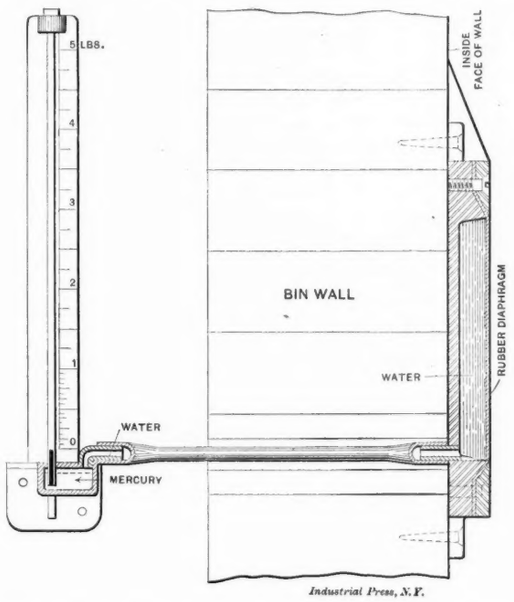
From the as yet incomplete reports of the Baltimore fire, February 7, it would appear that the best types of the so-called fireproof buildings suffered comparatively small damage structurally, although their combustible portions and contents were destroyed. This is notably the condition in the Continental Trust Company building, where a superficial examination has shown the building to stand plumb and the frame to be uninjured save in some minor instances where exposed to the flames. The fire has unquestionably demonstrated the superiority of brick, terra-cotta and other "fired" constructive materials over marble, granite and other natural stones that chip and crack when exposed to comparatively low temperatures. The fire has also demonstrated the weakness of fire-fighting apparatus of the old type depends for its efficiency upon the mere squirting of small streams of water from hose. All high structures must be equipped with standpipes with hose connections on each floor or sprinkler systems in the case of warehouses stored with combustible materials.

One of the serious problems of business in large commercial centers is the transportation of merchandise within the city limits. Horse-drawn trucks are slow and expensive under ordinary weather conditions, and often hopelessly impeded in progress by winter storms. Moreover, from a humanitarian point of view the use of the horse in city streets is to be deplored. But the automobile truck has not yet reached the degree of development that warrants its use for general purposes to the exclusion of the horse. It is peculiarly susceptible to delay by snow in winter and it requires a driver more capable and experienced than many firms can afford to employ. The logical method of handling the freight of a great city seems to have been quite unexpectedly developed in Chicago, and in a peculiar way. Chicago now has a system of tunnels, built originally for telephone and telegraph wires, which is also to be used for narrow-gage railway tracks for freight purposes. The gage of the tracks is to be 24 inches and the motive power will, of course, be electricity supplied by a third rail. The cars will be about 12 feet long over all, made of steel and iron, and will be of the double-truck, eight-wheel type. Since the network of tunnels burrows under most of the principal business streets it follows that all concerns on these streets may discharge and receive freight through their basements without exposure to the weather and without hindrance to public traffic. The Illinois Tunnel Company, controlling the project, expect to be able to handle not less than 50,000 tons of freight a day by the beginning of 1905. The system connects with six large railway freight depots, so that team work is entirely unnecessary. The advantages of the subway system will undoubtedly overbalance the great cost of such undertakings, and we may look forward to the time with confidence when such systems will be the rule rather than the exception in large cities.

THE PRESSURE OF GRANULAR SUBSTANCES ON THE WALLS OF DEEP BINS.

An interesting and valuable contribution to the meager data on the side and vertical pressures of granular substances stored in deep bins, with special reference to grain bins, was made in a paper read by Mr. J. A. Jamieson before the Canadian Society of Civil Engineers. The subject as it affects grain bins, has acquired an added significance since the construction of wooden grain elevators with rectangular bins is being abandoned in favor of fireproof elevators with circular steel bins. The sides of a wooden bin, if made strong enough to resist the lateral pressure, are amply strong to support the vertical pressure due to friction of the stored material. But a steel bin made on the water stand-pipe plan, might have a great excess of lateral or bursting strength and still fail by collapsing vertically.

It is pretty well understood by experienced grain elevator engineers that grain stored in bins of standard dimensions (12 to 14 feet square and 60 to 70 feet deep) produces comparatively small vertical loads on the bottom and lateral



Industrial Press, N.Y.

pressures on the sides, the greater part of the load being carried vertically by the side walls. It is also pretty well understood that the fluid pressure theory does not apply to stored grain and other granular substances, but very few understand how these effects are governed by the ratio of breadth to the depth of the bin, etc. The paper gives in detail the experiments made on standard size grain bins; also on model bins to determine the pressures, friction co-efficient, etc.

The matter of weighing the pressures developed on the sides of a full-sized grain bin was a problem of considerable difficulty. Several styles of weight scale-levers and beams were designed and rejected in favor of a hydraulic diaphragm and a mercury or water column gage of the form shown in the cut. A gage of this form was placed on the side a short distance above the bottom and one was placed in the bottom of a Canadian Pacific Railway elevator bin 12 feet by 13 feet 6 inches by 67 feet 6 inches which was filled with Manitoba wheat weighing 49.4 pounds per cubic foot. The grain was run into the bin in drafts of 30,000 pounds and the first draft had a clear drop of 70 feet. Each draft filled a section 3 feet 9 inches high and readings were taken after each draft. After standing 18 hours there was practically no change in the final reading of the gage, and when the grain was drawn off at the rate of 9,000 bushels per hour, the readings fluctuated considerably with a maximum increase of 4 per cent. over that obtained when filling the bin. When the valve was suddenly closed there was a slight increase of pressure and a corresponding decrease when the valve was opened.

The reading of the gage when the first draft was leveled off showed that the bottom of the bin carried 86.9 per cent. of the total weight of the grain, the remaining 13.1 per cent. being carried by the sides. The proportion of weight carried on the bottom steadily decreased as the bin was filled until when filled only 17.8 per cent. of the weight was carried on the bottom and 82.2 per cent. was supported by the friction of the grain on the sides. The side pressure tests were tabulated and give equally as striking results. With the first draft the equivalent fluid pressure would be 1.29 pounds per square inch; actually it was 0.34 pounds. When the bin was filled with grain, the total weight of which was 540,000 pounds, the side pressure was 2.46 pounds per square inch while the equivalent fluid pressure would have been 23.15 pounds.

A PARALLEL BETWEEN AMERICAN AND EUROPEAN INDUSTRIES.

Le Mois scientifique et industriel, October, 1903.

As a result of the importation into Europe of the first American machine tools, steam and gas engines and locomotives, and more particularly as a result of the exaggerating newspaper articles, which tend to give an inflated importance to the New World industries, the public as well as the manufacturers of the Old World are too easily led into an unwarranted admiration of American industrial methods. Certainly we have no wish to dispute the fact that American manufacturers are possessed of great initiative and a remarkable activity; a capability of making a quick decision and one that is almost always intelligently directed, a great capacity for work and a strong tenacity of purpose in attaining a desired end. What we wish to set forth is how American industrial practice differs from the European and from our own in particular.

The Americans are intolerant of that which is "good enough," and especially of mediocrity. If a plant is behind the times or the efficiency of a machine is not up to that of the most modern construction, the plant is remodeled and the machine overhauled and improved. Everything that can contribute toward the attainment of better results is considered necessary and indispensable.

In Europe, and especially in France, we have remained content up to the present with fairly good results; we fear changes that may modify the economic results, even though they are more satisfactory and certain, and we too frequently hesitate to take advantage of the benefits that may accrue from an improvement of the plant. Although the genius of our inventors and the scientific attainments of our engineers are fully equal to the Americans, yet it must be frankly avowed that what we do lack is that spirit of practical progress that characterizes all in America from the ordinary workman to the manager of a great industry. The old methods of doing business in Europe have not been changed for a long time, and in order to successfully compete in the markets of the world it is essential that we should work more in accordance with modern methods and with tools of the latest construction that will operate more rapidly and diminish hand work to the lowest notch.

The Americans have, furthermore, a special insight into manufacturing methods. They believe in constant progress. Hence, they build their machines and design their plants so that either can be readily renewed when it becomes necessary; and they always calculate upon a rather rapid depreciation. When this depreciation equals the original value of the machine they do not hesitate to throw the latter into the scrap heap when it is thought to be out of date and to replace it by another of the latest design, embodying the results of experience and acquired progress. It is this condition of affairs joined to that "spirit of rivalry," as Campbell calls it, that makes it possible for the American to compete in European markets with subsidized products, the price of labor and transportation, all of which should apparently make such a thing impossible. G. L. F.

VALUE OF SUPERHEATING FOR STATIONARY PLANTS.

Societe belge d'Electriciens, March, vol. xx., p 93.

The article is a very complete and interesting study of the use of superheated steam. The elements of the observations have been supplied by a large number of experiments made

by Messrs. Schroter and Vincotte with a tandem compound engine of 250 horse power. As a result of these tests the following laws have been formulated:

The actual saving due to superheating, or the reduction in steam consumption, is proportional to the amount of superheating; that is to say, to the excess of temperature of the steam as it enters the cylinders above that corresponding to that of saturation. It may be remarked, however, that this rule holds only for temperatures up to from 660 degrees to 710 degrees F., and that above these points the additional saving is inappreciable.

Steam jacketing has also been carefully studied.

With saturated steam, a jacket on the small cylinder effects a saving of 5 per cent. This saving diminishes with the use of superheated steam up to 480 degrees F. Beyond this the jacket causes a loss. As a result of a number of observations it appears that a saving is effected by a jacket on the large cylinder up to a temperature of 660 degrees F.

The saving of steam from superheating is not the one that should be considered. The true saving is that of the fuel, and here one is led to discuss the practical use of an independent superheater whose utilization of the heat of combustion is not usually very good. Various combinations of superheaters on boilers are cited with results that lead to the conclusion that a good deal of investigation is still needed before the final solution of the problem will be reached. For, as it is forcibly stated, the delicate point in the matter is not the engine, but the superheater.

With superheated steam it is of the utmost importance to look well to the jacketing of the piping and see to it that there are no bare surfaces. It is calculated that with an initial temperature of 575 degrees F. the fall in temperature is from .26 degree to .55 degree for each running foot of a well-jacketed pipe. For the same speed of flow, the larger the diameter of the pipe the less the cooling, because the surface exposed is less in proportion to the volume moving. On the other hand, it is desirable to give the steam as high a velocity of flow in the pipes as possible in order to avoid a prolonged contact with the metal. Owing to the lesser density of superheated steam, as compared with saturated, it can be given a velocity 30 per cent. in excess of that possible with the latter.

From the standpoint of practical operation there is no need to exaggerate the difficulties surrounding the use of superheated steam. It demands the use of proper lubricants, but they are already on the market; of metallic packing, and of steel piping, and not copper, so constructed that it has ample elasticity to compensate for all expansion and contraction.

G. L. F.

IMPROVED MANUFACTURE OF RIFLE BARRELS IN GREAT BRITAIN.

Mechanical Engineer, February 6, 1904.

For some time the Birmingham Small Arms Company have been experimenting, with the object of doing away with the method of hand "setting" gun barrels, and their experiments have terminated successfully. Although rifles have for a long time been made by machinery, the one thing which machines were unable to do was to produce a perfect barrel, and the barrel-setter remained an important person in the gun factory. On his skill of hand and keenness of eye depended the production of a barrel free from any inequalities of the interior surface, and therefore a perfect shooting weapon. There was a call for his services at almost every stage. First when the steel blank destined to become a barrel had been forged and was cold it passed on to the straightener, who with hammer and anvil effected the required adjustment. Then followed the drilling of the tube. This was formerly done from both ends simultaneously because of the slenderness of the drill in comparison to its length, and it may easily be imagined that under such a system a very trifling inaccuracy in the setting resulted in a failure to secure perfect alignment. If the drilling was not true—and very often it was not—the services of the barrel-setter again became necessary.

It often happened also that after rough-turning the tube had a crook which required further hammering to straighten it out. Nor did the trouble end there. The barrel had to be further turned until it was reduced to nearly the required dimensions, and then the bore had to be gradually enlarged. This was done with a reamer, and each stage of the enlargement was followed by more of the setter's delicate attentions, until at length a tube was produced as perfect as human skill could make it. Little wonder the barrel-setters were autocrats. Years of patient observation and application were necessary to qualify them for their important task, and their earnings were correspondingly large—these occasionally being as much as $50 a week, while in normal times the weekly wage was somewhere about $25. Apart from the expense, however, it was a cumbrous system, and, further, the experts were not satisfied with it, as however careful the setting might be the natural stress of the metal in the tube was altered by hammering, and it was liable to subsequent distortion under the influence of temperature such as was caused by rapid firing.

The search for a better method has involved considerable modifications in the earlier stages of the manufacture of the blank from which the rifle barrel is made. Instead of waiting for the forged rod, which is ultimately to be converted into a barrel, to cool before it is straightened, this operation is carried out in the smithy while the steel is red hot and sufficiently ductile to permit of modifications of shape without the introduction of serious stresses. Great care has also been bestowed upon the perfection of the machinery which deals with the blank. In a very large percentage of cases it is found that the first turning of the outer surface produces an absolutely true bar, and in the matter of drilling the company have made a distinct departure from the practice of some other firms. Instead of putting drills to work from each end toward the middle they drive straight through with one drill. In order to facilitate the cutting, a constant stream of oil is forced down a channel in the drill, which not only serves as a lubricant, but on the return journey washes back with it the metal fragments which the tool has cut away. Mr. A. H. M. Driver, the chief engineer to the company, and his assistant, Mr. G. Norman, are the joint patentees of various ingenious devices introduced at this stage, which materially increase the accuracy which the majority of the barrels show after undergoing this first drilling.

It is necessary, however, to inspect all of them, and in the old days this is where the barrel-setter's art would have come in. But the setters of the old school are all gone, and more scientific methods prevail. The barrels are placed in a sort of rack, which holds them tilted end up to the light. But the light is not permitted to stream in unobstructed, as was the case with the old method. It is admitted through a circular aperture, which produces a number of perfectly ring-shaped zones of light and shadow, and not a cone shadow, such as the old setter had to guide him. As the operator of the machine gazes down it, the barrel is given a spin, and now even a novice can tell whether the workmanship under examination has been true. If it is, the rings revolve concentrically; if it is not, then they revolve eccentrically. In the latter case there is no hammering to be done, but by the turn of a screw the machine puts on the pressure required to rectify the irregularity, not in one spot, as the hammer blow would do, but evenly over a fairly large portion of the barrel. By this method, it is claimed, the barrel is not injured, and is consequently unlikely to suffer deflection from truth in the final reaming and turning.

In addition to the greater accuracy secured by the new method of testing and setting, the process has resulted in a considerable saving of time and expense. Under the old conditions it was not uncommon for the barrels to undergo seven or eight or even ten settings by the hammer, and the time thus occupied was considerable. Now, however, the process occupies 50 per cent. less time. In addition, as the drilling and boring machines are automatic, two or three can be placed under the charge of one person, while the setting machine has enabled the operations which were performed by the highly-paid setters of the old school to be done by ordinary machine hands. The process of straightening can also be successfully done on the barrels of the sporting shot-gun.

PNEUMATIC TOOLS FOR RAILROAD WORK.

Extract from Paper read by Mr. Thomas Alcorn before the New England Railroad Club, December 8, 1903.

The pneumatic hammer is the most widely used and best known pneumatic appliance in shop service, employed for chipping, calking, beading flues and riveting. Averaging 10 to 13 pounds in weight and operating at a speed of 1,100 to 2,000 blows per minute, it may be readily calculated how powerful an agent this tool becomes in the hands of a competent operator—and competence is readily acquired by an ordinary grade of labor, a peculiarly advantageous feature applicable to all air tools. The value of the hammer as a saver of time and labor is so universally conceded that the time has passed where it was deemed necessary to submit comparative figures, especially as much depends upon the conditions of operation and the efficiency of the air plant; but we may say, briefly, that one man with a pneumatic hammer, in chipping, etc., will do as much as three to four men working by hand. A ⅜-inch chip has been removed by one of these hammers from a boiler plate ½ inch thick at the rate of 7 inches in 58 seconds.

In addition to the chipping of metals, calking of seams and joints, the hammer is naturally utilized for a wide variety of purposes requiring a rapid percussive blow—from the dentist's mallet to the driving of drift bolts. Among special uses for the hammer of particular interest to railroads may be mentioned the driving of spikes and removing scale from locomotive crown sheets. For spike driving the ordinary long-stroke hammer held by the hand is provided, with a set suited to the spike head, but for the removal of scale from crown sheets the hammer (or jam riveter, as it is technically called in this instance) is adjusted between grate and crown sheet by means of a pipe extension, and in the stationary position so provided quickly performs the work by the rapid succession of blows which it strikes. In riveting on a standard fire-box leg containing 253 ¾-inch rivets, a long-stroke hammer will drive all of them in 9 hours at a cost of 48 cents per hour, or a total for the entire fire box of $4.32. This same job by hand work will take 15 hours at a cost of 73 cents per hour, or a total for the entire job by hand of $10.95; or if the same job was done by hand-snapping the rivets, it would take 12 hours at a cost of 63 cents per hour, or a total cost of $7.56. Thus it will be seen that a saving is made on this particular job of $6.63 over the hand-driven rivets, or $3.23 over the hand-snapped rivets. In another instance 1¼-inch rivets were driven in a boiler which stood 360 pounds pressure, with a pneumatic hand hammer, at about one-third the cost of old methods.

The air drill (or reamer), next to the percussive hammer, is the most widely known pneumatic appliance, and has an extensive range of utility. Almost numberless are the shop operations the labor and time in performing which have been reduced by this portable, compact pneumatic motor, that will fit in almost any space, employing an angle gear if necessary, and which is always ready at the instant. Easy to hold and guide, wonderfully lightening arduous tasks, it is not surprising that this tool does not share the customary antipathy of the workman to labor-saving devices. Among special uses for the drill motor is its adaptation as a casting cleaner, portable emery wheel, polisher, and for driving cylinder boring bars, valve facing machines, motor hoists, operating turntables, jib cranes and elevators.

In the car shops, working in wood, the pneumatic drill, running at a higher speed than the one used on metal and weighing from 10 to 25 pounds, will bore a 2½-inch hole through 5 inches of oak in less than 20 seconds, an excellent record, as all will agree who have ever attempted to bore a 2½-inch hole in oak. The foreman of car construction of one of the leading railroad shops in the country states that by the use of a wood boring machine his men are able to bore all the holes necessary in the erection of a standard coal car, 192 in number, in 15 minutes. Allowing 3 minutes for shifting the air supply from one side of the car to the other, this leaves a net period of 12 minutes for the boring of the holes. This he considers a remarkable performance, and so far in advance of hand work as to make comparison out of the question.

One of the newest pneumatic devices, with which doubtless many are not familiar, is the hydro-pneumatic wheel press, consisting of an air cylinder operated in conjunction with an oil-filled piston carrying tail rod or intensifier, the arrangement affording an unusual effect in power concentration. It is not the intention to enter here into a detailed description of this device, which must be seen to be appreciated, but its value in any form of work and in any position where an extraordinary amount of power must be exerted in a quick operation is unique. For removing crank pins, or as a punch, or for hoisting, or as a car jack, this machine covers a wide range of usefulness. Occupying less space and working with a considerably less consumption of power, this device represents a marked advance over any form of tool heretofore employed for the purpose.

RE THE WATCHMAN'S WATCH.

Extract from Paper read by Mr. A. Newman, December 8, 1903, before the Annual Meeting of the Field Club of the Illinois Fire Underwriters' Association in Chicago.

"About fifty years ago one Buerk, a manufacturer of high-grade clock movements and other horological instruments, living in a small village in the Black forest of Germany, invented what is known as the portable watchman's clock. This man Buerk was a genius, the more so that he had no intention to make a watchman's clock for the market, but invented this device for the sole purpose of controlling his own night watchman. He had a watchman whose name was Fritz Traumer, a very suggestive one and no misnomer, for Unser Fritz would dream the night away instead of patrolling his beat. So Buerk took it into his head to devise ways and means to checkmate the peaceful occupation of his guardian by putting one of his small movements in a locked brass case, placing upon the center or hour wheel a hand and a cylinder or drum so arranged as to travel with the hour hand. Upon the periphery of the drum he fastened a paper tape properly ruled and marked as to hours and fractions of hours and cross lines to denote the stations. Opposite the correct time was fastened a forked spring with pointed prongs at its outer end. Each prong stood opposite one of the rulings of the paper tape. At the stations to be visited he placed chains about twelve inches in length, and upon the end of each chain a key was fastened. The watchman carried the clock to the stations, inserted the keys, each of which, when turned, would raise one of the prongs and press the point of the same into the paper slip.

"Each key striking a different prong, would naturally cause a prick mark to be made on the different lines in the paper slip. The little village made merry over the piece of ingenuity of Herr Buerk, and Fritz, for the time being was the butt and laughing stock of the community, but the host of the Wurtshaus grieved with Fritz, for the keg did not run dry quite so fast as in the days before the telltale clock was installed in the Buerk plant, and Fritz allowed his dreams to run in different directions and became a somnambulist while he was doing his beat, and as he was walking and dreaming in this aggressive fashion he came to the conclusion that Buerk did not know much, after all. The chain was very easily opened with a pair of plyers, the keys taken off and carried to the Wurtshaus, and mine host should be happy again. In the course of time Buerk naturally awoke to the fact that his place was not well watched, and discovered the method by which the watchman circumvented his own craftiness. So he set to work upon a scheme to beat the watchman's game. This he did by making a safety link chain which could not be taken apart after having been put together without taking each link from the further end of the key, and as the further end link was fastened at the station by screws and seals, the watchman was unable to carry away the keys. This safety chain is very well known and is used for almost everything that a chain can be adapted for. It still bears the name of 'safety chain' and derived its name from its first use. Buerk never knew the value of this chain in any other way than as an auxiliary for his watchman's clock apparatus. This only goes to show how an inventor's mind, starting off in a certain groove, will get so fascinated with his work, looking neither to the right nor left, and thus

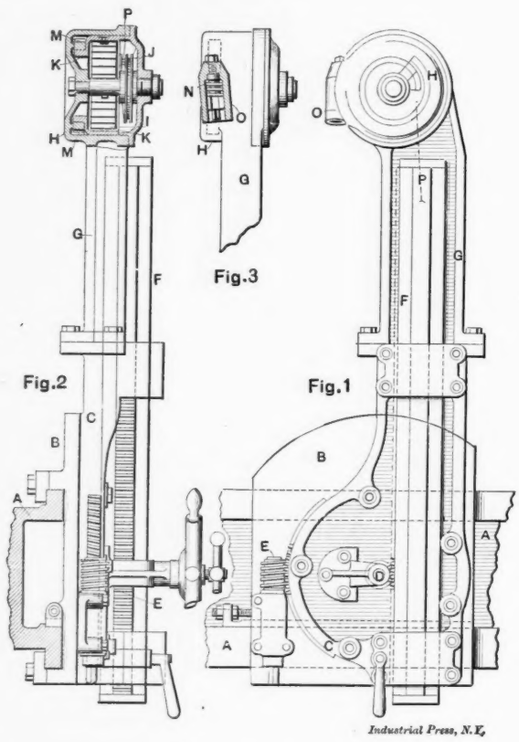
miss the tide at the flood. The safety chain would have made Buerk one of the wealthiest men in Germany had he patented it, but Buerk felt too much interested in the watchman's watch, and immediately placed them on the market. He reaped a nice income from their sale and left his family in good circumstances."

SPRING COUNTERBALANCE FOR THE BARS OF BORING AND TURNING MILLS.

Mechanical Engineer, February 6, 1904, p. 177.

This improvement, proposed by Mr. J. E. Mathewson, of Brodheath, near Manchester, relates to the counterbalancing of the tool bars of boring and turning mills. The usual practice in counterbalancing these bars is to do it by means of weights, chains and pulleys, but Mr. Mathewson proposes to make each head self-contained and to balance the weight of the bar by a coiled spring mounted in a suitable box at the top of the slide which is extended for this purpose.

Fig. 1 is a front elevation of the improved ram or tool holder, Fig. 2 is a side elevation of the same partly in section, and Fig. 3 is an outside view partly in section. *A* indicates the cross slide of the machine, *B* is the saddle and *C* is the ram frame, which is pivoted at *D* to the saddle. This frame is provided with teeth on its outer edge, and by means of the



worm *E* the frame *C* may be rocked on its pivot *D* to any angle required by the workman. *F* is the ram or tool holder which slides in suitable guides in the frame *C*. To the top of the frame *C* is adapted a support G, which carries at its upper end a box *H* containing a coiled spring *I*, a fusee *J* or equivalent equalizing device, and bearings for an axle *L*. *K* is a ring which is capable of rotating in the box *H*. Outside, on one edge, this ring *K* is provided with external teeth *M*, with which gears a worm *N* contained in a suitable box *O* secured to the side of the box *H*. This worm is capable of being rotated by means of a key or otherwise. One end of the spring *I* is attached to the ring *K*, and the other end to the axle *L*, on which is also keyed the fusee *J*. To the fusee *J* is attached one end of a flexible connection, such as a cord or chain *P*, the other end being attached to the ram *F*. The tension of the spring is regulated according to the weight of the ram by rotating the ring *K* by means of the worm *N* and the external teeth *M*, the worm serving to retain the ring in the position in which it is set.

PATENT LAW ADMINISTRATION.

In Switzerland, where we may look for the most enlightened laws and policy in such things, the patent laws were for a time abrogated, and again restored on nearly their former basis, so that the equity and expediency of such grants can scarcely be called in question. There is also the further fact that British laws, from which the system originated 280 years ago, have changed but little in all that time. From England the system of patent grants for inventions spread widely over the world, our own dating back something more than a century, the present indices reaching to 1790. It is an interesting study to examine the development of this patent system and the impediments which had to be overcome because of the paucity of technical knowledge and skill required to administer such a bureau in a new country, where science and the technical arts had a narrow foothold until comparatively recent times.

Down to 1870 or later than that, each inventor had to supply a model of his invention, in order to enable the officers of the Patent Office to understand its nature and its manner of operation. Not only this, but the drawings supplied had to conform to the model, and, as models were naturally crude, the result of this can be imagined. No other country, that I am aware of, except Canada, adopted such a feature, but in Canada the drawing and model were not required to correspond, so the model happily dropped out, though a little later than in this country. This method, which called out a good deal of ridicule in other countries, has left us a legacy of useless lumber, which still occupies a good deal of room in the cramped space where the Patent Office work is carried on. Some of these models have interest historically and some of them are well made, but destruction would be a proper treatment for three-fourths of the whole.

The operation of the patent laws went on with measurable uniformity in different countries until within a few years past, when the German Bureau initiated a reform that will no doubt extend to other countries where technical knowledge is sufficiently advanced to permit such a system. This change is fundamental in its nature, but not very easy to explain in a popular way. It consists in a measure of novelty and utility on grounds almost the reverse of present practice in this country. Our laws permit or grant patents on the means or agents of production only, that is, on contrivances or discoveries that produce results; and particularly bar patents on principles or on modes of operating. This, it will be seen, opens the door for endless patents on nearly the same thing, with slight differences that often turn upon mere phrases of speech.

The German government grants patents on results, or, in their terms, on "new technical results," paying but little attention to means or implements. Claims to express compendiously the subject matter of an invention are limited to one that must involve what is called a "unitary concept." Other claims may be added, not more than three, explanatory of the first. This plainly involves a complete change of system.

It would be an enormous innovation in this country for our astute patent agents, who can write twenty permutation claims on a nutcracker, but it is an advance to a higher plane, is logical and must commend itself to all who will analyze the true spirit and intent of patent grants for inventions. This juggling system of "permutation claims" is a distinguishing feature of modern practice in this country. It is a device that had its origin with patent agents, and because the claims in American patents were construed separately and independently. It is the reverse in England, where a patent falls with each and any of its claims; and in France, where until very recently, a patent required no claim at all separate from the body of the specification. This latter system permitted full discretion to the courts, and this discretion, I am glad to say, has been seldom abused. Our own courts have to deal with words and cunningly devised phrases instead of the essence, nature and scope of an invention, and, having a dread of subjects they cannot possibly understand beyond a construction of terms, the justices are apt to follow each other in their decisions on any issue. This was the case in the celebrated

Abstract of paper read by Mr. John Richards before the Technical Society of the Pacific Coast, November 6, 1903, and published in the Association of Engineering Societies' Proceedings.

Woodworth patent suits early in the last century, when there were twenty-two suits at law over the invention of a "combination of feeding rollers and rotary cutters," which invention was embodied in the British patent of Bentham, 1793.

I am recounting these features of practice for two reasons: First, in order to show how difficult it is to administer the patent laws, and especially procedure in the Patent Office; and, secondly, to invite comment on some means of attaining a more intelligent and just procedure in that department.

The statute law relating to patents is printed on 32 small pages containing about 15,000 words, and is, in itself, quite simple and understandable; but this law is supplemented by endless decisions that attempt to fit the application of these laws to the circumstances of industrial inventions, and it is doubtful whether any human power could codify this maze and bring it into a harmonious relation with the arts. The "Rules of Procedure," 214 in number, emanating from the Commissioners of Patents and their advisers, is a more-extensive matter than the law, occupying 100 printed pages and about 47,000 words, much of which should be embraced in the statutes. These rules are intended for the instruction and guidance of the examiners and patent attorneys. They are often changed and extended to meet the constantly recurring problems that arise in an attempt to fit laws and administrative rules to science and the arts, which is, in the nature of things, impossible.

This impediment is fundamental and perhaps insuperable. The two things cannot be assimilated. Science and the arts are computable and exact. They deal with definite dimensions, fixed natural laws and skill, the latter meaning a personal recognition and acquaintance with these qualities, or quantities, and with the modes of their operation. Statute law is inexact, uncertain and mutable. It does not deal with dimensions or exact quantities of any kind; not even, except in an indirect way, with modes of operation. One may read through a law treatise, even on patent law, and not find in it a single thing that has a base in anything exact and proved, except, perhaps, a chemical formula. Men skilled in statute laws are seldom or never qualified to deal with the technicalities of the industrial arts, and, consequently, not capable of determining the nature, scope and relations of inventions.

Conversely, those skilled in the arts and accustomed to the exact results of science are apt to look with indifference and suspicion on the unstable laws and procedure relating to patents for inventions. The basis for this work must be facts, measurable and computable; things must correlate, must have constant sequence and must be uniform. Law and the practice of law are none of these things, but are arbitrary, uncertain and frequently illogical. It is not easy to make the difficulties of administration clear, but your own consideration of them will, no doubt, confirm the fact that neither this nor any other government has resources from which to draw officers to administer a patent bureau according to the spirit and intent of the laws.

Germany, which established excellent and numerous technical schools about 50 years ago, is at this time nearer than other countries to providing a corps of officers competent to pass upon and award patents for inventions. These technical schools had no marked influence over the industries of the country for 30 years or more, but now we can see their effect in many ways. In Saxony alone there are 287 industrial schools. The chemical industry will show the influence of this kind of training. In Germany there are more than 6,000 establishments making chemical products, employing 135,000 workmen. One of these, at Manheim, which I have seen, employs 6,000 workmen and 148 chemists, besides the clerical force. With few natural resources for chemical products, Germany managed to send into this country last year $14,000,000 worth of such manufactures.

Under such circumstances, where there are thousands of qualified men available to conduct this department in a patent bureau, we should naturally look for good practice; and, as I have before pointed out, their system is likely to produce imitation in other countries. It is likely that an impediment to this system will be found in its paternal nature. The law provides that each patent granted must include an "invention," and, as no law can define what an invention is, this point is left to the decision of the officers of the bureau at Berlin, qualified by the provision before named, that an invention must produce a new "technical result" and consist of a "unitary concept." This is vague, but is as far as law can go. It reaches the point where personal knowledge of the arts must begin; in other words it is the point where technical knowledge and impartial administration must take up the work, and brings us to what we call "procedure," in which a German officer is supposed to ignore nationality, forego his prejudices and act impartially. Time will show whether this be possible.

In this country the enormous activity of industrial production furnishes a field that absorbs the technically trained people, and few are available for the Patent Bureau. On the contrary, the legal profession is overflowing and aggressive, and, as patents for inventions are commonly understood as a matter of law instead of technical discrimination, the result is confusion. An examiner-in-chief, of which there are three who sit as a board of appeal in contested cases, receives the sum of $3,000 a year; a principal examiner, the head of a division, gets $2,500; a first assistant examiner, $1,800 a year, and from this the salaries run down to $1,200 a year for fourth assistant examiners. There are 200 officers who come under the head of examiners, and in all between 700 and 800 people employed by the bureau, a large proportion of whom seem to come from the New England States.

It is an amazing example of routine work, done by rule and apparently without personal discretion—by rules that have grown out of the conduct of the office and the circumstances of procedure. Changes—even the slightest—are ventured upon with timidity, and, while it is easy to discern much that seems illogical and wrong, it would be hard to see how any successful change can be made without starting at the very beginning with a new law relating to patents for inventions.

The functions of examination and rejection are the salient features of our patent system. The rejection of a patent is in its nature a paternal act, wherein the government assumes a function that properly belongs to the citizen. The applicant is not permitted to use his own judgment as to what he can maintain and defend, but is taken care of, so to speak, and instructed as to what he shall have the privilege of maintaining, by the judgment of an officer who can destroy but cannot confirm. This is paternalism and establishes a common conclusion in the minds of applicants, and, indeed, in the minds of all except those who have studied the patent laws, that they are to receive with a patent a confirmed right. Patent agents all over the country will bear evidence to the existence of this opinion among their clients, who look upon the examiners as holding in their power a favor to be bestowed or withheld. "Get all you can" are the instructions, but these same people are generally very cautious respecting their claims in other countries, where personal responsibility is the same. It may at first thought seem a strange proposition that the rejection of patents should increase the number and lower the character of applications, but I am satisfied that it does so. Thousands of applications are made that would never appear if the applicant and his attorney were made responsible, as in England, for the scope and novelty of inventions as presented to the bureau. I judge of this matter by the fact that patents are more respected there than here, and are seldom repeated and more often sustained in the law courts.

A primary examiner in our Patent Bureau, instead of acting in what may be called a professional capacity, performs routine duties in which his individuality is usually eliminated. He does not even sign his decisions and has no power to amend them; no matter how mistaken they may be they must go permanently into the record. But, strangest of all, he exercises a "triple function," so to speak, being a whole tribunal in himself, acting as witness, counsel and judge. He prepares the evidence, presents it as attorney for the government as against the client and then passes judicially upon his own finding by deciding whether the applicant shall or shall not have the privilege of defending his claims in the law court. These duties, instead of being professional and advisory, are arbitrary; they consequently fail to command the confidence

of inventors and put the bureau in a false position before the country.

I am inclined to think that our patent system, or the manner of its administration, has, in some cases, exercised a restraining influence on certain arts. As a case in illustration: Among those interested in the subject it is a matter of common knowledge that inventions pertaining to hydraulics have for many years past met with scant encouragement in the American Patent Office, and that, as an example, our water-wheel practice, a very extensive interest, is in certain types distinctly behind that of France, England, Germany and Hungary, a fact that appeared when the Niagara Commission met at London in 1890 to consider water wheels for the Niagara Falls scheme. American makers presented no plans that the commission considered, or even mentioned, in their report, except one tender from San Francisco for tangential wheels, which I had the honor to prepare. Pressure turbine practice in this country, except as to one type, the centripetal or central-discharge one, came from France, and the best examples in use here were made under the patents of Fourneyron and Jonval, while the Girard type, that was best suited for use at Niagara and for high heads, was not until 1893 made in this country at all, and was then so badly made as to fail, so that no impulsive-acting wheels of any kind were made, down to the evolution of the tangential type on this coast.

How a country where so much water power is employed under all kinds of heads and conditions could go on until a few years ago without any manufacture of the type of water wheels known as the Girard class of unfilled or partial turbines (one of the most common in Europe) will appear if we examine the history of some early inventions here.

In February, 1853, fifty years ago, Mr. Jearum Atkins, of Illinois, I think, filed in the Patent Office at Washington an application for an improvement in water wheels of the unfilled or impulse type, and in his specification set forth, in the form of a well-written treatise, the principles on which his wheels operated. This application was promptly "rejected." No unfilled turbine had been seen before, and Mr. Atkins, being a poor man without resources, and an invalid besides, was not able to prosecute his case by appeal or otherwise, and, as the patent could not issue because of "rejection," he was unable to work his invention, except to make one very successful wheel; so the invention was strangled, so to speak, by rejection.

About 1860, seven years later, Messrs. Escher, Wyss & Co., of Zurich, Switzerland, began making water wheels of the same type, and the practice rapidly extended all over Europe, especially in France and Switzerland, and, as I have remarked, came back to this country in 1890 through the plans of the water wheels at Niagara, which were made from drawings furnished by Messrs. Faesch & Picard, of Geneva, Switzerland, who, with four or more other European firms, tendered full designs for the construction of these wheels.

In 1875 Mr. Atkins' invention was somehow resuscitated at the Patent Office in this country and a patent was issued to him, but too late to do him any good or to aid in founding the manufacture here. Mr. Atkins, when I last heard from him, was living at an advanced age in the Mechanics' Home in Philadelphia. He was an original inventor, perhaps the first to discover and explain what are called impulse or open-turbine wheels, in which the discharge vents are larger than the inlet ways, and was the first, in this country at least, to lay down in a clear manner the principles involved in this kind of water wheels, which include the tangential type extensively made and used on this coast.

Suppose the patent of Mr. Atkins had been issued in 1853, even with all the objections that were urged against it in the Patent Office, no one will doubt that the inventor's representations and his better understanding of the subject would, in either a business way or even in suits at law to defend his invention, have been quite sufficient to work and sustain his patent; and if this had been done, this country would have reaped a great reward from the invention. It is not contended that the examiner should have known that a turbine water wheel would operate when not filled and when the discharge passages had double the area of the inlet ways. A recorded opinion to that effect would by no means have destroyed Atkins' patent if it had been issued at his request, but "rejection" took away his power of utilizing the invention and destroyed it, whereas it is quite sure the courts would have sustained his claims, notwithstanding the action of the Patent Office.

I could go on and show that in centrifugal pumps, gas engines and other important manufactures procedure in the Patent Office has hindered progress. Just at this time I have failed to have a distinction made between impulsive-acting and pressure fluid machines operating by steam. Both types seem to be in one class, although their manner of operating is essentially different. It is like the old problem of 1853, or, rather, is the same problem over again, and the result is that there is not a manufacture of impulsive-acting steam engines in this country that is not either an imitation of European practice or paying tribute to foreign inventors. The first successful engines of this type, of which I have any knowledge, were made about eighty years ago by William Avery, of Syracuse, N. Y., an uncle of Prof. John E. Sweet, who made fifty or more, and, as I have just remarked, there is not at this time a separate division in which these engines could be classed in the Patent Office.

In 1895 a distinct invention in ignition apparatus for gas engines was made by Mr. George E. Hoyt, of San Francisco, in which the "time function" was regulated by resistance and distance of flow of the gases into a tube having a small bore about one-thirtieth of an inch in diameter. This invention was presented and persistently prosecuted before the Patent Office for two years. The inventor sent to the office tubes 5 inches and others 30 inches long, with affidavits to show that both had been on the same engines under the same conditions, and that it was the contracted bore, resistance and consequent velocity of flow into the tubes that determined the time point of ignition.

The claims were rejected by the primary examiner on irrelevant references, and by the examiners-in-chief, and was abandoned because the parties in interest concluded, and yet believe, that the invention was opposed on technicalities and not considered on its merits as an invention. There is no intention to disparage or underrate the eminent attainments of a large number of officers in the bureau, but even these are bound by a routine of rules and precedents that prevent personal and responsible action in technical matters. They are bound to consider terms and forms of speech that are purposely made entangling and obscure, and not the essential facts.

I do not feel qualified to suggest a remedy for the features of our patent system that have been criticised, but strongly suspect that the German laws and procedure are a distinct advance in some of the objects to be attained by a patent system. I believe that the number of patents granted in this country, about half a million a year, could be well reduced to one-third as many by the requirement that each patent should relate to a new "technical result," and not a means alone; that patent attorneys should not be admitted to registry or to practice in office procedure unless competent and qualified, as in other professions; that the actions of the primary examiners, which are now a part of the permanent record, should, with amendments, be printed with each patent; that the power of final rejection be taken away from the primary examiners and exercised by different officers, capable of judging impartially of new technical results; that the appeal of tribunals of the bureau, now wholly inadequate, should have more time and facilities for their actions; that the salaries of the chief and first-class examiners should be doubled, so as to command higher technical qualifications for this intricate and responsible work.

* * *

We never look forward with any degree of expectancy to the time when an active trade shall have been developed in drilled, bored, tapped or reamed holes *per se*, but evidently the hole-making industry has reached a state of development in another industry quite surprising since we note in a daily journal the advertisement of a buttonhole factory for sale in Rochester.

MACHINE SHOP EQUIPMENT.—7.

SHOP TRANSPORTATION EQUIPMENT.

OSCAR E. PERRIGO.

The question of the transportation of stock and material from the point of its receipt from outside sources to the various departments where it is to begin its regular transit from the raw material to the finished product, of transferring this material from one department to another during its progress through the shops, and of its final transit from the department where it is finished to the storehouse, for safe keeping or for shipping to customers, is an important matter. For if closely followed through all its various stages, and the expenses accurately kept, as to the capital involved in the appliances necessary, the proper maintenance of these facilities in good working condition, and the labor necessary for their successful operation, it would appear to be a far larger item of expense in the general account than would usually be supposed from a superficial consideration of the question.

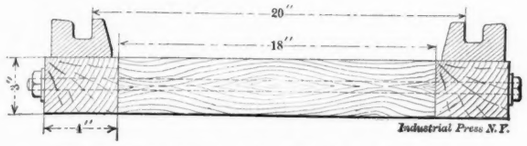


Fig. 3. Cross-section of Straight Track when Laid.

This is a matter upon which careful planning is needed in all its bearings, as any saving in this respect, while still rendering good service, is an actual saving, and unlike the reduction of the cost in building a machine for the market, is not liable to effect a deterioration of the real quality or value of the product. This does not mean that the service can, or should be made inefficient in order to avoid expense, but rather that it should be well planned, well administered, prompt and efficient in every way, yet without a useless appliance or an unnecessary man employed in it. For instance, the progress of the work through the different departments should be so arranged that, as far as possible, it may be really progressive from the raw material to the finished product, with as little "retrograde movement" as may be. In this way a considerable percentage of the work of transporting materials and stock in progress may be saved, rendering a less extensive equipment of cars, trucks, etc., necessary, as well as a smaller force of employees for handling them.

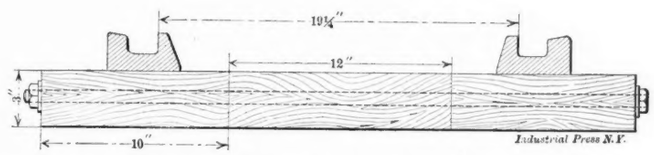


Fig. 4. Cross-section of Curved Track when Laid.

In arranging the different departments of the plant here shown due consideration was given to this matter and they were carefully planned with this end in view, as will be more fully pointed out in the articles on shop management, which will succeed this series.

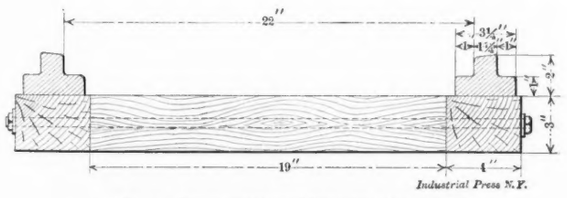


Fig. 7. Cross-section of Straight Yard Track.

In the list of appliances that may be classed as transportation facilities, we may mention traveling cranes, overhead trolleys, shop cars on tracks, cars on yard tracks, hand trucks, and small tool conveyors. Of these, the traveling cranes may be those propelled by a shaft running the entire distance of their travel, by those carrying an electric motor for their propulsion, and those of small capacity worked by hand, with a chain reaching down near the floor. Again, as to lifting power, they are operated by the shaft above-mentioned, by a motor, or by chain blocks with the usual differential chain wheels or other similar device.

Overhead trolleys running on I-beams may have a small motor mounted upon them furnishing the power for their propulsion as well as for their lifting power. Frequently those of moderate capacity are pulled along by hand, and the loads lifted by chain blocks operated by hand. These trolley tracks are so constructed that they can be put up in straight lines, curves, switches, crossings, etc., which render them very convenient for light work, and they occupy but little room overhead, and none at all on the floor. In some cases, however, existing overhead obstacles such as shafting, belting, countershafts, etc., preclude the use of either the overhead trolley or the traveling crane; in others the weights are not sufficient to demand the expense of a traveling crane; in still other locations several traveling cranes would be required to cover the space to be operated in. Then there are other situations in which lack of height prevents the use of the overhead trolley system.

Shop tracks for the accommodation of cars of the usual size, say, 34 inches wide and 5 feet long, will be of the same gage as the yard tracks, or about 20 inches, so that the shop cars or heavier and larger yard cars may be used on the whole system. These cars may be propelled by small electric motors in the form of an electric locomotive, which is simply a car fitted with two motors operated by a storage battery, but more often they are pushed about by hand, particularly when loaded with less than 2 tons weight.

A balance crane may be erected on a car for yard or shop use, and may by this arrangement be capable of picking up and carrying a load up to a ton or two. It is very useful in locations where power for loading is not available.

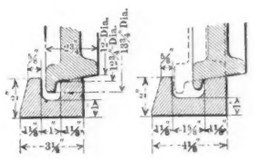


Fig. 5. Fig. 6.

Four-wheeled shop trucks with the front axle pivoted and handled by a tongue, should have their wheels so constructed and located as to properly run upon the shop tracks as well as upon the floors.

The Franklin portable crane is simply a small jib crane on wheels, which may be moved about the shop as easily as a hand truck. Its capacity is from one and a half to three tons.

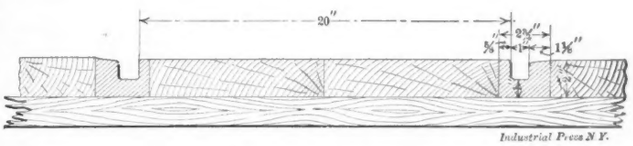


Fig. 8. Cross-section of Straight Shop Track.

It readily lifts and holds the load at any point so that it can be wheeled to any desired location. It is now made also with a gasoline motor, or an electric motor run by a storage battery for both propulsion by traction wheels and the power for lifting—making a very complete and portable power crane for many ordinary shop purposes. It will be found a very convenient and useful addition to the shop equipment.

The traveling cranes provided for in the various departments do not seem to need any detailed description. There are many excellent ones in the market and they should be selected with a view to the special requirements of each case.

In considering a system of tracks for yards, and the system for the construction of cars for use upon these tracks, the Hunt system is probably the best and most complete of anything in the market, particularly when heavy work is to be undertaken. However, for moderate loads a more economical method of construction may be adopted, and one that may be built in the shops without a great outlay for patterns or spe-

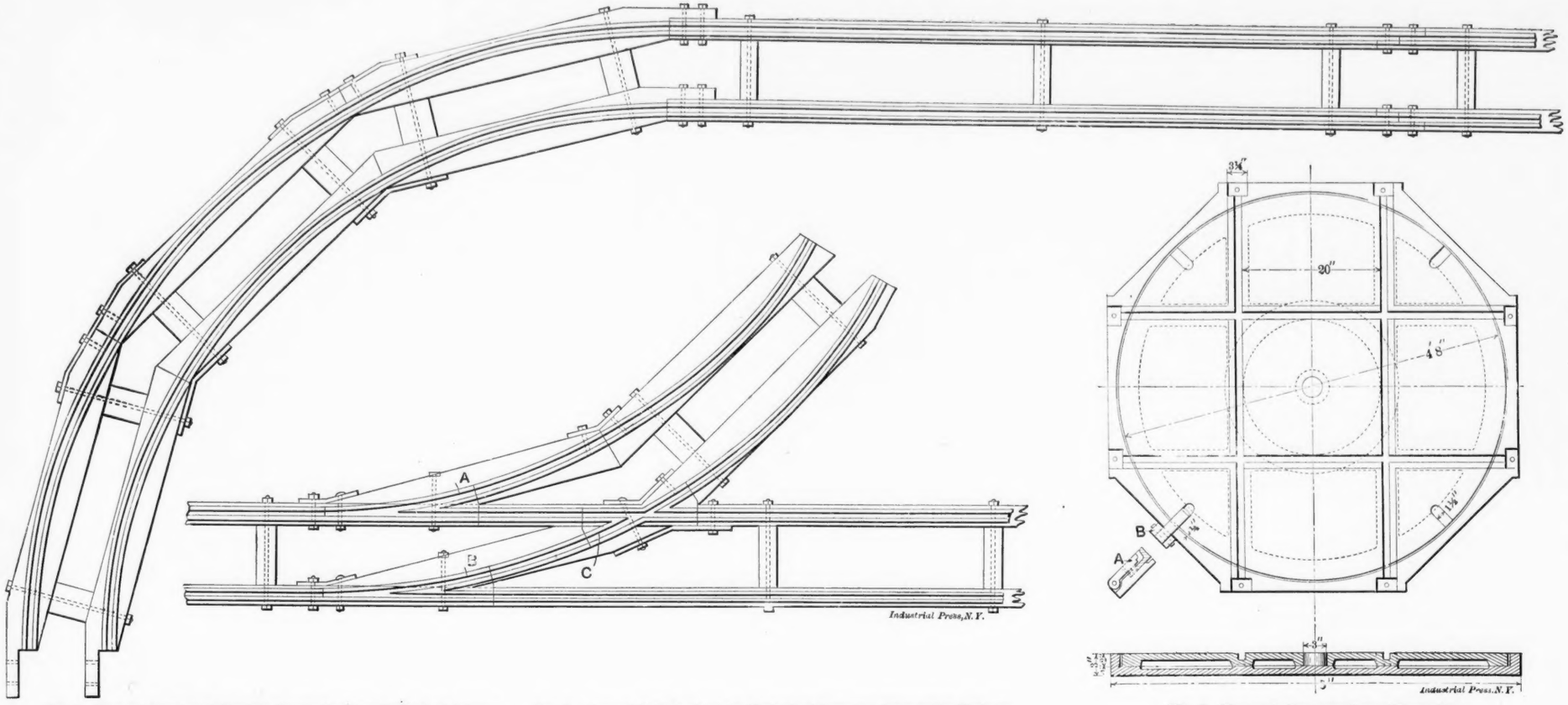


Fig. 1. Plan of Curve and Straight Track showing Method of Joining.

Fig. 2. Plan of Switch showing Method of Securing Supporting Timbers.

Fig. 9. Plan and Cross-section of Turntable.

cial tools. Metallic ties are no doubt the ideal method for laying track on the ground when steel rolled track is used. Yet a cast-iron track, properly constructed and properly supported will be found very practical for every-day service in a plant of such a character as the one under consideration. Again, where track is to be laid on upper floors it would not seem advisable to use the heavy plate track made of cast iron on account of its considerable weight. Much of this is not necessary for the purpose, particularly when moderate loads are to be transported, as is usual with work done on the floors above the first; and all excess of weight is not only detrimental, as unnecessarily loading down the building, but adds needlessly to the expense. In fact the principal requirements of a floor track would seem to be these: First, it should be on a level with the top of the floor, so as not to offer any obstruction to the workmen going from place to place, or to the passage of hand trucks over it. Second, it should be of such moderate weight that it may be laid down on any floor of the building without overweighting it. Third, it should be of such simple construction that an ordinary mechanic may build one, put it in operation and repair it. Fourth, it should be so designed that cars having a fixed wheel base may readily run around its curves without undue friction. Fifth, it should be of such depth that it may be easily laid down by cutting through the usual two-inch plank floor of the ordinary machine shop, or laying the track first, in the case of a new shop being erected, and fitting the floor around it.

A track designed and constructed in conformity with these conditions is illustrated in the drawings accompanying this article. Fig. 1 is a plan of a section of straight track joined and secured to a 90-degree curve. Fig. 2 is a section of straight track in connection with a left-hand switch. Fig. 3 is a cross-section of the straight track, on an enlarged scale. Fig. 4 is a cross-section of curved track, also on an enlarged scale. All of these views show the track and its supporting timbers as arranged and laid in the shop yards. Fig. 5 is a cross-section on a still larger scale, showing the relation of the straight track and a portion of the rim of a car wheel. Fig. 6 is a similar section showing the position of the wheel on the outer rail of a curve.

Upon a straight track it is a simple matter to construct wheels or track that will run properly and work freely with-

out undue friction or grinding upon the edges of the rails. When the curves are considered quite a different problem presents itself. The outer rail upon a curve being considerably longer than the inner rail, means must be provided for compensating for this difference so that there may be no slipping of either wheel of the car when passing around the curve, in the case of the usual four-wheeled cars whose wheel axles are journaled in fixed boxes. To provide for this condition the groove in the track is considerably widened, whereby the wheel flange may have ample space to run from side to side. The wheel is constructed with an inclined face, representing a short section of a cone. It is considerably wider than the portion of the track upon which it runs, as will be seen by referring to Figs. 5 and 6. The action of this arrangement is as follows: When running on a straight track the position of the wheels on the track will naturally be midway, in consequence of the reversed position of the inclined tread of the wheels. When the car arrives at a curve the natural tendency is toward the outer rail. This tendency will throw the outer wheel up on its largest diameter and at the same time bring the bearing of the wheel on the inside of the curve to its smallest diameter. This variation of diameters will be sufficient to compensate for the increased length of the rail on the outer side of the curve and the car will run smoothly around it. The difference between the width of the groove in the straight track and that on the curves is arranged for by narrowing the groove in the curved track to the proper width in the final 8 or 10 inches from the end where it joins the straight track. The dimensions of the track are given in Figs. 5 and 6. All curves are of 12 feet radius to the inside rail of the curve, and it would be better to make them 14 feet if possible, as the longer the radius the easier the cars will go around the curves, no matter what system of construction of cars is used. For switches the plan will be as shown in Fig. 2. Special castings are constructed as shown at *A*, *B*, and *C*, and to these the curved and the straight track will be joined as shown. Of course, these special castings must be made for right and left switches, necessitating two patterns of each piece. A shifting tongue to the switch need not necessarily be provided for cars carrying light loads, as it is a comparatively easy matter to guide them as desired. These yard tracks are laid upon timbers which are bedded in flush with the top of the ground. For the straight track they are 3 x 4 inches and secured, as shown, by cross pieces and through-and-through bolts ⅝ inch in diameter. For the curves 3 x 10-inch timbers are needed, and they are similarly fastened. In attaching the straight sections to each other the timbers are lapped and bolted as shown. On the curves, switches and similar places, iron straps fastened by bolts or lag screws are used to connect them, as shown in the drawing.

In laying the track, the frogs and crossings of the switches should be first put in place and connected with the straight pieces of track, which may be easily cut to length on the power hack-saw. Such curves as are necessary to connect the switches to the straight track are then put down, care being taken to have the proper pieces of curved track to connect with the straight track so as to properly fit the groove in it. It will be necessary to have a gage by which to locate the second track, after the first line of rails has been put down and correctly lined up.

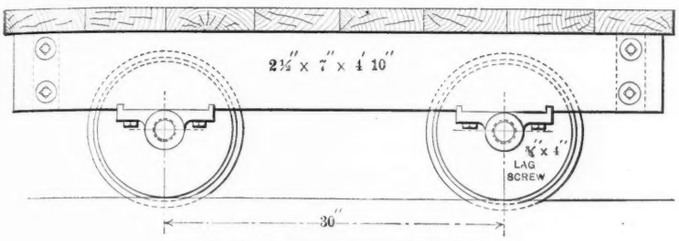


Fig. 10. Side Elevation of Tram Car.

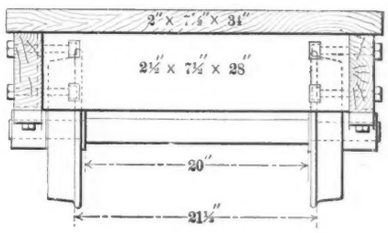


Fig. 11. End Elevation of Tram Car.

Another form of track is shown in Fig. 7, for the straight yard track. It has the advantage of having no groove where water, snow or ice may find a lodgment and impair the usefulness of the system. This form of track may also be constructed for the curves, by placing it the proper distance apart to permit the wheels to run up on their largest diameter on the outside rail and their smallest diameter on the inside rail. Grooved track will be needed at the switches.

In fastening down these tracks heavy, flat-head wood screws are used for track having a groove, and lag screws for track constructed as shown in Fig. 7.

In Fig. 8 is shown another form of track for shop floors, letting the rails in flush with the top of the floor. The sides of the track are square with its lower surface, so as to have it fit up to the edges of the floor planks without cutting them to an angle. Curved track is similarly made, the groove being wider but the edges of the track vertical, as shown.

It will be noticed that all this track is of cast iron, as being a cheap and convenient material. Steel rails laid on ties may be used for the straight track if desired, and cast iron rails for the curves and the switches, but the expense will be considerably more, and the additional outlay is not necessary if light loads, say, under two tons, are to be carried.

Fig. 9 shows a plan and cross-section of a turntable. It is composed of two castings; the lower one, or bedplate, being for convenience, made of octagonal form, and having formed in it a proper recess for receiving the turntable proper, which is journaled or pivoted upon a center pin cast upon the bed-

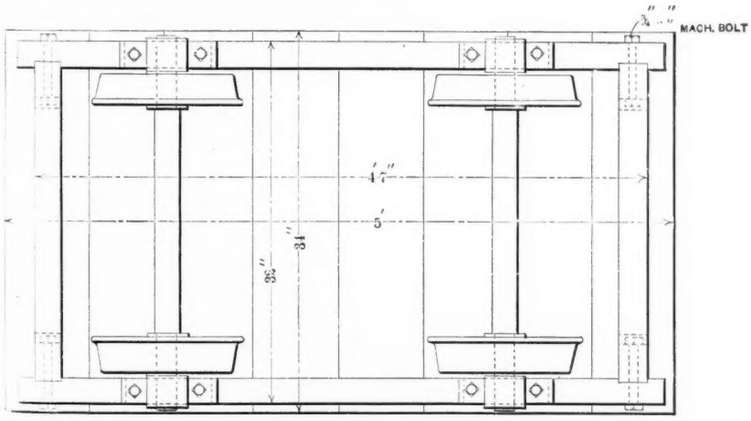


Fig. 12. Plan of Under Side of Tram Car.

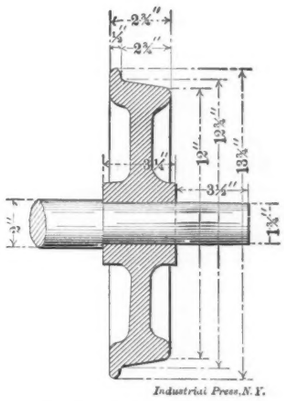


Fig. 13. Section of Car Wheel.

plate. Two annular bearing surfaces are provided, in addition to the boss around the pivot pin. At the ends of the track-grooves are formed suitable pockets for receiving the ends of the track and holding them in line with the turntable grooves. At one side is shown a simple and convenient latch, *A*, pivoted flush with the top of the bedplate in the projections, *B*. Four recesses are formed in the top of the turntable proper, into any one of which this latch may be dropped as desired. For heavy loads the annular bearing surfaces are sometimes provided with grooves and hardened steel balls

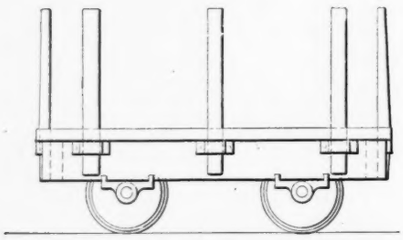


Fig. 14. Car with Removable Stakes.

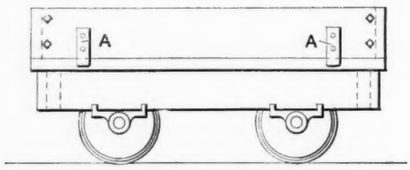


Fig. 15. Car with Removable Box.

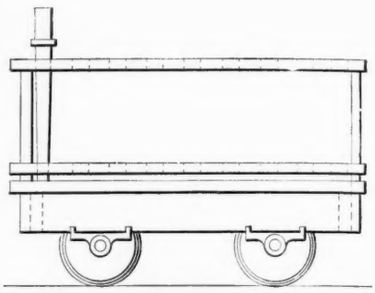


Fig. 16. Car Arranged for Special Work.

introduced to eliminate a large percentage of the friction, but in this case the additional expense is hardly necessary, if the bearing surfaces are kept well slushed with a thick grease. It will be better to face up the bearing surfaces in a large lathe that they may be true and evenly bearing surfaces, but this may be omitted if castings can be had which are straight and true.. Where these turntables are used in yards, holes should be left in the bedplate casting to permit the water to run through, and thus avoid as much as possible the danger of their freezing up. The bedplate should be supported by 3 x 5-inch timbers placed directly beneath the tracks in both directions, these being usually used in connection with tracks at right angles to each other.

It will be noticed that all of this track work is so simple and plain that the work of laying it may be done by any good carpenter; and that the effort is made to have all the arrangements of both track and cars of the most simple and inexpensive character consistent with utility and durability.

A car suitable to run on these tracks is shown in the drawings, in which Fig. 10 shows a side elevation; Fig. 11, an end elevation; Fig. 12, a bottom view; and Fig. 13 a section of one of the wheels, with a portion of the axle. Sufficient dimensions are given to enable any good mechanic to construct them. This car, constructed of oak planks, put together in the manner shown, will be amply strong for loads up to two tons. The top planks are fastened down with ⅝ x 4-inch lag screws, the heads with washers under them, and let in flush with the top of the planks so as to offer no obstructions. The frame is fastened, as will be seen, with ¾ x 6-inch machine bolts, the nuts of which are placed in mortises. The axle boxes are solid and fastened to the car frame by ¾ x 4-inch lag screws, and are also held rigid by ribs let into the side timbers, as shown.

So far we have considered only the plain platform car, which will be used for perhaps a majority of the transportation of material and stock about the plant. But there will be a demand for cars for special work, where a car of special construction and adapted to the conditions will be vastly more convenient, and better suited to the purposes for which it is used. As it has been the aim in designing and arranging this system of shop and yard tracks, and the necessary equipment for them on such a plan, that all the work of construction and installing may be done on the premises, and at moderate expense, the same idea has been carried out in reference to what may be dignified in railroad parlance as the "rolling stock" or equipment for it. With this idea in view, the different styles of cars represented in Figs. 14, 15, 16, 17, 18, 19 and 20, have been designed to meet the requirements of actual practice in the regular routine business of the machine shop and the various departments necessarily connected with it.

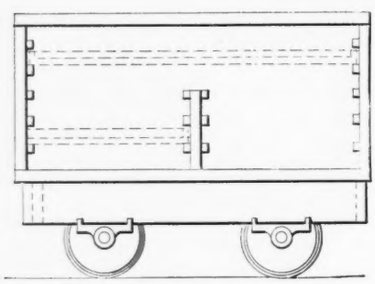


Fig. 17. Car Arranged for Trays.

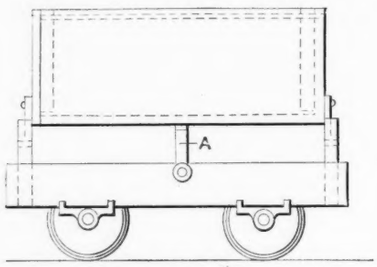


Fig. 18. Side Elevation of Dump Car.

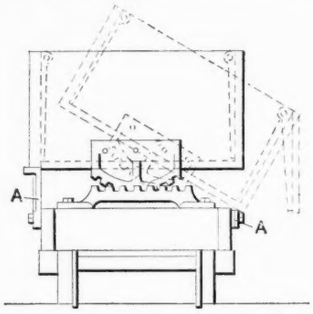


Fig. 19. End Elevation of Dump Car.

The plain platform car, suitable for use in the shops was seen in Figs. 10, 11, 12 and 13. This form is the basis of all the cars shown in the succeeding illustrations. Fig. 14 shows a car with stakes, supported in ordinary cast-iron stake pockets bolted to the frame of the car, proper recesses having been cut in the top planking or platform of the car to accommodate them. These stakes may usually be 20 to 24 inches in height from the top of the car platform, and 2½ x 3 inches at the largest part. Such a car will be useful for transporting lumber in long or short lengths, for forgings, for small boxes, or bundles of manufactured stock to be shipped, as well as many other uses which will readily suggest themselves. In Fig. 15 is shown an ordinary platform car having a box of 1½ to 2-inch plank, held together by ⅝ rods, as shown, and held in place on the car platform by the straps *A A*, so as to be read-

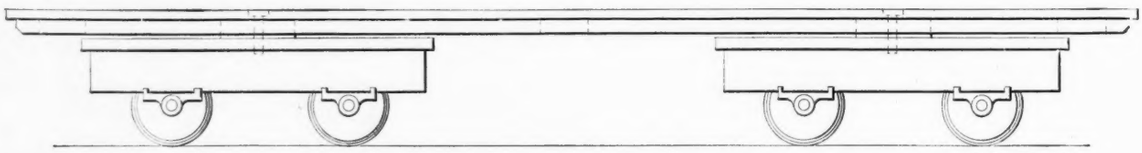


Fig. 20. Double Car. Two Cars and a Special Platform.

ily removable and adaptable to any of the regular sized cars. This form of car is very useful in transporting lots of small castings, forgings, drop forgings, partially finished work and any kind of stock and material which may be handled roughly and is not too large or clumsy for piling in such a box.

Fig. 16 shows a car specially arranged for transporting spindles, short shafts and similar work which have been finish turned, ground, or have passed through such operations as render their careful handling necessary. In this case a subbase of 1¼-inch plank is placed two or three inches above the car platform, and a similar one at a proper height above it to accommodate the work to be handled. These supporting planks are perforated with holes of a proper size to suit the work. They are supported and held in place by plank ends, corner posts, or in any convenient manner. These supporting shelves or frames may be attached to the car as a part of it, or they may be made removable like the box shown in Fig. 15. This form furnishes a safe and convenient method of handling this class of work.

Fig. 17 shows a car arranged with racks for holding a series of trays for the reception and transportation of small, finished parts, or parts going from the machines to the polishing room, plating room, finished parts storeroom, etc. Such cars may be constructed to take trays the full size of the car platform, one half, or one third of it, or for any combination of these sizes, the trays sliding into their places like the printer's type cases. They will be found very convenient for handling and for accounting for small parts in their transit through the shop.

Figs. 18 and 19 show a dumping car, arranged from one of the regular cars, with the platform omitted. As will be seen, the box or body of the car is not pivoted upon trunnions, but supported upon a cast-iron rack, with cast teeth, at each end of the car, this rack being engaged by a toothed segment fixed to the car body as shown. The object of using this toothed device in preference to simple trunions or pivots, is to carry the car body toward the side where the load is to be deposited when the car is dumped. The device is simple and effective. The side supports, *A A*, are pivoted to the frame of the car and are used to hold the car body in its normal position. The sides of the car body are pivoted at the top, as shown in Fig. 19, and held or released by a simple latch at their lower edge. A small safety chain may be added on each side to prevent the car body from becoming unshipped by careless dumping. These cars may be used in transporting coal, ashes, coke, molding sand, and all similar materials which may be quickly unloaded by dumping. Those used for carrying coal to the boiler room may have a horizontal shelf on a level with the bottom of the car body, and on the side toward the boilers. However, a more convenient arrangement will be a solid box of three sides, or two ends and a side, built upon an ordinary platform car, the side toward the boilers being pivoted at the bottom instead of at the top, as shown. This will be convenient to shovel coal from. But the dumping car, as shown, should be used for the removal of ashes. For either coal or ashes the car bodies should be lined with sheet iron.

Fig. 20 shows a large car formed by placing upon two ordinary flat cars, a platform constructed of 2-inch planks, running lengthwise, and held together by cross bars 2½ inches thick, and a similar bar running lengthwise on each side of the platform, and within two inches of its edge. Such a platform may be from 34 to 42 inches wide, and from 7 to 10 feet in length, according to what use it is intended for. Cross bars, at least 12 inches wide should be built with the platform, at the points over the centers of the cars, and through these is placed a "king bolt" as shown, which furnishes a pivot upon which the separate cars turn, the same as the trucks of a railroad car. It will be readily seen that such a car will carry double the weight of the ordinary platform car as the weight is distributed upon eight wheels instead of four.

Cars for use in the yards may be heavier and longer than those used in the shops if the conditions demand such increase. For instance, the cars may be made 38 inches wide and 6 feet long instead of 34 inches by 5 feet. The frames should then be of 3 x 8 inch instead of 2½ x 7-inch timbers. The wheel base should remain the same, in order to facilitate the passage of the car around the curves.

As to the number of cars necessary for the equipment of the entire plant, much will depend, of course, upon the particular character of the work to be done, but in a general way it may be stated somewhat as follows: Of the ordinary flat cars, as shown in Figs. 10, 11 and 12, there will be needed 16 cars, distributed among the different departments. Of these, six at least should have stake pockets and a sufficient number of stakes provided for them to give ten stakes to a car. There should also be 10 of the removable boxes shown in Fig. 15 for use on them is needed. There should be 6 dump cars for use in the yard, foundry and boiler house. The special cars shown in Figs. 16 and 17, and such modifications of them as may be necessary, will be used mostly in the machine shop galleries, and their number will be determined to a very large extent by the kind of work that is to be done. There should be at least two of the platforms shown in Fig. 20, to be used on any of the flat cars. The number of cars above mentioned are considered really essential to the proper handling of the usual classes of stock and material, but a larger equipment will doubtless be advisable whenever the first cost is not closely limited.

* * *

NOTWITHSTANDING GREAT ODDS.

Orlando M. Grimes.

Editor MACHINERY:

There fell from the ranks on February 2 a man who, though but a humble workman, was yet in some ways so remarkable as to be worthy of notice as an example of true grit and manly independence.

Orlando M. Grimes, a Vermonter by birth, was, while serving his time as a machinist apprentice in 1863, caught in the shafting and before it could be stopped had both of his legs and his left arm broken, and so serious were his injuries that upon recovery, which did not take place for nearly a year and a half after the accident, he could not take a step longer than 12 inches nor raise either foot higher than 6 inches; and to walk a hundred yards required so much effort as to throw him into a perspiration even on a cold winter day. The small bone of his left arm was removed and his left hand and arm thereby rendered almost useless. Under these discouraging conditions he finished his apprenticeship and started out as a journeyman, and he succeeded so well that he could always command the pay of a first-class workman, both by reason of the quantity and the quality of his work.

All the later years of his life he worked in the tool-making branch of the business and among the highest grades of the work. He was naturally more efficient in machine work than in bench work, yet at the bench he could do as much and better work than the average workman.

It was instructive to any one to watch him maneuver to perform the different operations upon a piece of work and to see how he made every move count. He never asked for help in any work that was usually done by one man, though it was often offered to him.

He was of a deeply religious nature and regularly gave one-tenth of his earnings to charitable and religious organizations.

It is greatly to the credit of human nature that in making application for work he was only upon a few occasions spurned from a shop door by reason of his physical condition.

He has worked in a large number of the shops of the Eastern and Western States, and it is probable that many of MACHINERY's readers will remember him. He is survived by his widow, who lives in Arlington, N. J.

Brooklyn, N. Y. J. R. GORDON.

LETTERS UPON PRACTICAL SUBJECTS.

TO OUR CONTRIBUTORS.

We wish to call the attention of some of our valued contributors to what is considered a serious breach of faith in the publishing business, and that is, sending substantially the same contributions to two or more publications with the expectation of receiving payment. Any contribution to a reputable journal should be regarded as its own unless rejected and returned. Practically all contributions to this department are paid for upon publication, which, of course, makes them the property of THE INDUSTRIAL PRESS. Sending the same contribution to another journal is substantially the same as selling one article to two buyers. Moreover, it puts the journal appearing last in a bad light—that is, of apparently appropriating matter from another journal without credit.—EDITOR.

RE BEVEL GEAR FORMULAS.

Editor MACHINERY:

In reviewing the November, 1903, number of MACHINERY, I once more read the article "Bevel Gear Formulas," by J. D. Adams. I would like to ask Mr. Adams through your columns why he wrote formulas 3, 4 and 5 as he did. I would prefer to write them as below, since they would then be less confusing to the beginner.

$$\phi = \tan^{-1}\frac{D_1}{D} \qquad (3) \qquad \tan\phi = \frac{D_1}{D}$$

$$O = \tan^{-1}\frac{2}{P\sqrt{D^2 + D_1^2}} \qquad (4) \qquad \tan O = \frac{2}{P\sqrt{D^2 + D_1^2}}$$

$$I = \tan^{-1}\frac{2.314}{P\sqrt{D^2 + D_1^2}} \qquad (5) \qquad \tan I = \frac{2.314}{P\sqrt{D^2 + D_1^2}}.$$

However, I, for one, wish to thank Mr. Adams for his article. CHAS. E. MILLER.

Akron, Ohio.

RE THE DIE THAT CRACKED IN HARDENING.

Editor MACHINERY:

A few words regarding the die as described by "D. M. M." in the "How and Why" column: I agree fully with Mr. E. R. Markham's explanation; and I also think that D. M. M. can consider himself extremely fortunate that only one crack appeared, as a die containing over 200 holes is a very difficult piece to harden. Even if luck should favor D. M. M. in hardening his next die without *cracking*, I think it is safe to state that it is impossible to harden a die containing over 200 holes and have the holes remain in the same *relative position* as before hardening.

The writer suggests to D. M. M. that a very satisfactory die, accurately spaced when ready for use, can be made by using a block of machinery steel, recessed to allow the insertion of small tool steel bushings. By making the die in this manner a broken die can be easily repaired simply by forcing out the broken bushing and inserting a new one. On the other hand, if a die is solid and one of the dies breaks, the whole die (200 holes) has to be annealed, greatly increasing the chances of cracking when re-hardening, to say nothing of the holes changing their positions, which necessitates bending the punches in order to align same with die, etc. Then, too, the piece punched is not the same as those previously punched.

All things considered, a die containing a number of holes, especially a die with over 200 holes, should never be made solid. FRANK E. SHAILOR.

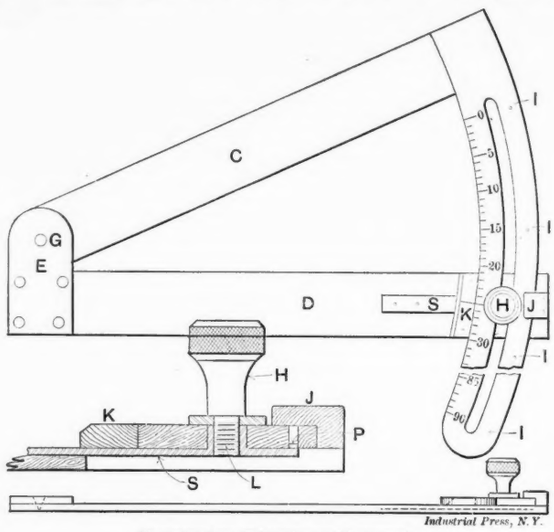
Great Barrington, Mass.

A COMBINATION TRIANGLE AND PROTRACTOR

Editor MACHINERY:

The accompanying sketch shows a plan and section of a combination triangle and protractor that the writer has found to form a very useful drafting instrument. The two blades, *C* and *D*, lie flat on the board and are connected at their inner ends by the plate, *E*, and at their outer ends by the quadrant, both of which lie on the top of the blades. The plate *E* is riveted to the inner end of the lower blade and hinged to the upper one, there being a small hole through the rivet, *G*, in order to locate a point on the drawing board, or for passing a pin through into the board, when the pin can be used as a pivot. This hole is countersunk from the upper side to facilitate locating it over a given point.

The quadrant is riveted to the upper blades and slides freely on the lower one and is clamped firmly by the knurled head screw, *H*, or kept in place by the spring, *S*, with its pin, *P*, coming up into one of the holes, *I I I I*, which are shown at 0, 15, 30, etc., degrees, but may be placed at whatever angle the protractor is most frequently used. The small plate *K* fits the graduated edge of the quadrant and comes even with its top surface, making it easy to adjust the graduations with the line on the plate *K* very accurately. The spring *S* fits into a recess in the blade *D*, and is riveted firmly to the same on its plain end. The lug for *L* projects into



Combination Triangle and Protractor.

the long slot in the quadrant and presses against the washer. By screwing down the knurled head screw *H* the quadrant is clamped firmly to the blade, *D*, and by loosening this screw slightly the quadrant slides freely back and forth. By backing the screw a little further out the pin, *P*, on the spring, *S*, presses against the under side of the quadrant and springs into the first one of the holes *I I* that comes above it. The quadrant is prevented from being raised from the blade by the small plate, *J*, which overhangs its outer edge. The quadrant being on top of the other blades is high enough to pass over the top of the T-square, making it a practical tool to use in any place where ordinary triangles are used.

Watervliet, N. Y. M. H. HALL.

UNIQUE DRAFTING SET.

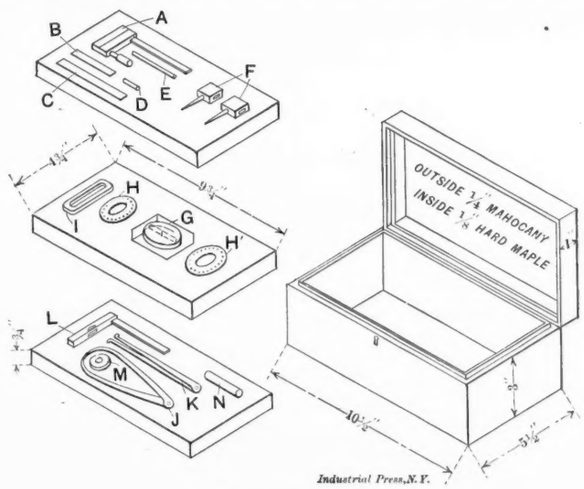
Editor MACHINERY:

Some little time ago I saw how a man could carry the instruments that he might need for almost any business or service in a very small and handy box, and I feel sure it will interest some readers of MACHINERY.

It is a somewhat common but nevertheless erroneous impression that the young man who goes into the office to make drawings will have nothing to do but trace or make pencil sketches. This may be true in some cases, possibly in large works, where, of course, a great many of the young men do not find very much opportunity to get around the works, but in the smaller plants it is different. There even the last comer is often called upon to go out and measure up something that has been brought to a state approximating perfection, or perhaps to measure up something that is so very far from the state of perfection that it has broken down. In such cases a man may need a great many things not contained in the sets of drawing instruments listed in the catalogues of the dealers. The particular set that I wish to describe consisted, exteriorly, of a neat little wooden box having a spring

lock and key. The owner commonly kept immediately inside on the top a nice leather pocket case of ordinary drawing instruments and under the space provided for this pocket case there was space for three small trays. Each tray was made of a piece of well-seasoned wood, covered on the under side with a piece of thick plush or velvet. The upper side of the piece was carved or recessed amply large for the instrument to be carried there, and over these recesses and all was secured another piece of velvet. The edges and ends of each piece of wood alone were left bare, but the edges and ends of each of these pieces, as well as the inside of the box, were neatly finished in hard varnish. As a ready means of lifting each tray there was secured from end to end a piece of heavy black braid about ½ inch wide. In the trays, of course, were the various instruments that are so commonly needed and often so hard to find, and all these trays, being of the same size, anyone could be put above the others for ready use.

We will now describe them in order as they were commonly kept. The upper one carried a 6-inch beam micrometer, *A*; a 4-inch and 6-inch scales, *B* and *C*; 1-inch and 4-inch standard test piece, *D* and *E*; and a pair of beam compass points, *F*. The next tray was fitted with a pocket compass having a bar needle and inclinometer secured to a square brass-plate having one edge turned up (as we often see used by geologists) *G*, and on each side of this were two circular wire gages of different makes, *H H'*, and at the end was a coil of fine



Unique Drafting Set.

magnet wire, *I*, that could be used with the compass to make it a temporary galvanometer. In the lower tray were a pair of ordinary calipers (inside and outside), *J* and *K*; a small steel square with a level, *L*; and a 25-foot steel pocket tape, *M*, divided to feet, inches and 16ths on one side and metric measurements on the other side. On the side of this tray there was also a strip of brass about No. 24 gage, divided on each side into 100 equal parts and pivoted in the center so that it might be used as a scale beam. In a suitable recess was a tin case, *N*, containing a set of metric weights, which, together with the graduated brass strip made it easy to obtain small weights quite accurately and quickly.

Burlington, Iowa. F. W. SALMON.

THE VALUE OF THE COOPER-HEWITT LAMP FOR PHOTOGRAPHIC AND OTHER USES IN THE SHOP.

Editor MACHINERY:

Anyone who has had much to do with photographing machines knows how often the conditions are adverse to good work. The machine is usually located in a part of the works where the light is very poor, and if the machine is of such a size that moving it to a better lighted part of the works is practically an impossibility it always taxes one's ingenuity to "light the object," as it is termed. As the varying qualities of light and shade are what makes the picture, it is under any circumstances a matter calling for much skill to so graduate the light at one's service as to get results that are satisfactory.

Firms that find it necessary to photograph most of their machines make a provision for such work by providing suitable skylights, screens, etc. The use of artificial lighting methods has been tried, but seldom with much success. I would therefore like to call attention to some photographs made by the light of the so-called Cooper-Hewitt lamp. One

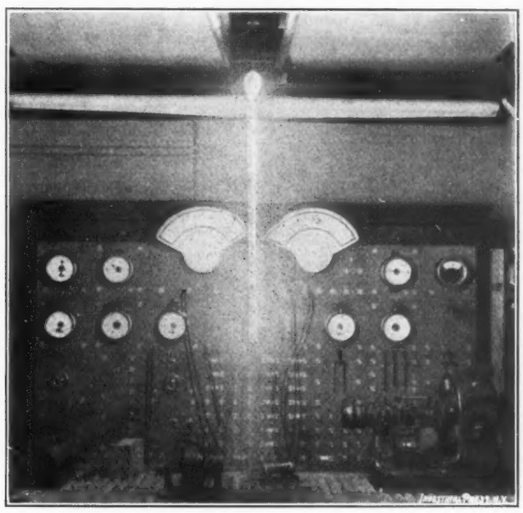


Fig. 1. The Cooper-Hewitt Lamp.

lamp only was used in this work, and the work was performed in a large hall with walls painted such a color as would least help reflect actinic light. The conditions, it will thus be noted, were adverse to good lighting and show what might occur if the lamp was used in an ordinary shop room.

The photograph from which the half-tone, Fig. 1, was made, shows the relative position of the lamp and the machine to be photographed; Fig. 2 shows the result when used to furnish light for photographing the machine; and Fig. 3 demonstrates that with only one lamp a large hall may be so evenly lighted as to show up in the negative with fair results.

This light has already been adopted in some of the portrait studios with excellent results, and usually three lamps mounted in a grid or frame are so used. The light is not only soft and mellow to the vision, but soft mellow effects in

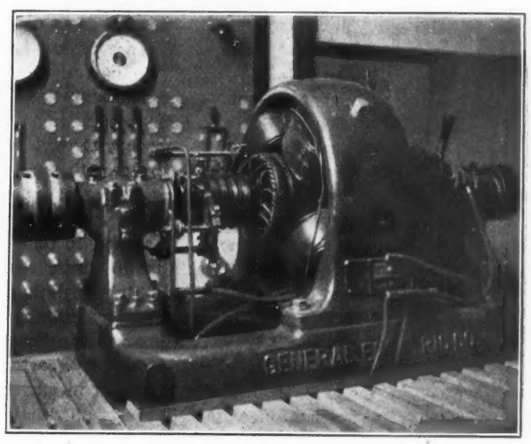


Fig. 2. From Photograph taken by the Cooper-Hewitt Light.

lighting the subject can be obtained. Using the light for photographic purposes, one is struck by its uniform distribution as compared with other artificial lighting. Fig. 3 shows this, by the furthest corners being nearly as well lighted as those nearer the lamp. Reading also is possible at distances from the lamp that seem wonderful when other lighting is considered.

The lens used in making these photographic exposures was stopped down to F 16 and the length of exposure was ten seconds in all three exposures. The plates were Seeds, N. H.,

and were treated in development as if exposed by sunlight. All exposures were made several hours after dark and with no other lights burning.

It would seem as if this lamp might be of great use to those who find it necessary to photograph objects in places where the light is uncertain, or perhaps a minus quantity altogether.

For the benefit of those who have not seen this lamp a

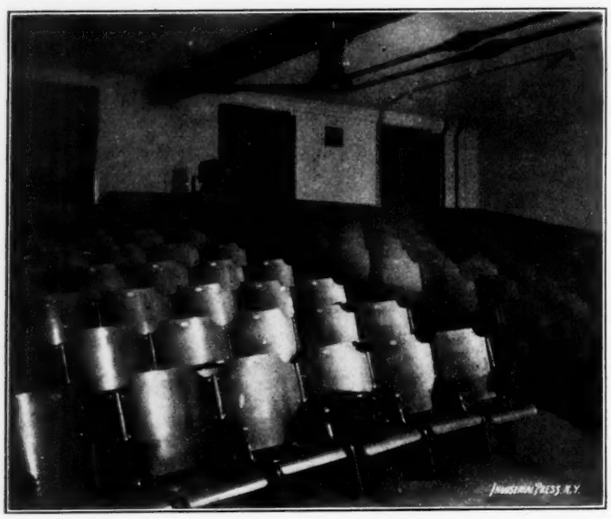
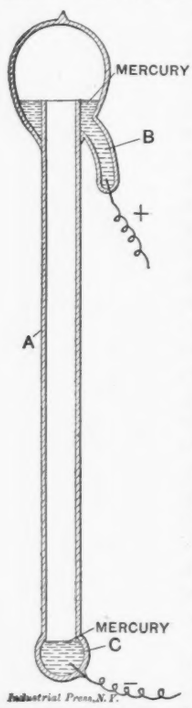


Fig. 3. From Photograph of Lecture Hall taken by Cooper-Hewitt Light.

brief description of it may not be amiss. The lamp as shown in Figs. 1 and 4 is a glass tube of less than two inches diameter and about four feet in length, with a bulb blown upon one end. Wires are fused into the ends of this tube when it is closed, and enough mercury is introduced to form a small puddle at its lower end. The air is exhausted from the tube until a very perfect vacuum is formed. The lamp thus presents the appearance of a long glass tube closed at the lower end and with an incandescent bulb blown upon its upper end, closing that also. In use, one or more of these lamps are held in a light frame by simple clamps embracing the tube near its ends. This frame is hung in such a manner as to permit of swinging the lamp up beyond the horizontal for starting. To start the lamp it is swung up until the puddle of mercury is in the upper bulb, the current is applied and the lamp is swung down in such a manner as to form a thin stream of mercury the entire length of the tube, forming a path for the passage of the current between the ends of the tube. As the stream of mercury breaks, vapor of mercury is formed, and the current continues to pass through this vapor, rendering it highly luminous, and giving off a very powerful light. As it takes a very high potential to break down or disintegrate the mercury, certain coils and apparatus are needed in starting, but when once started, the lamp runs with an exceedingly small power.



Industrial Press, N.Y.

Fig. 4. Vertical Section of Cooper-Hewitt Lamp.

Fig. 4 represents a vertical section of the lamp and shows something of the design. *A* is the glass tube and, as will be noticed, it projects into the condensing bulb that closes the upper end. This allows a puddle of mercury to remain there and the upper puddle *B* is the positive electrode, while the puddle at the lower end, *C*, is the negative electrode.

As the mercury vapor condenses in the upper bulb it trickles over the end of the tube, falling to the lower puddle, and is again vaporized. When working properly the tube is comparatively cool and the lamp gives off little heat.

A seven hundred or eight hundred candle power lamp uses no more power than that sufficient to run say three thirty-two candle power incandescent lamps. The vapor of mercury being in a vacuum, no waste is possible, there is no noise, and no flickering, and when the lamp is once started it requires no further attention. The light produced comprises orange-yellow, lemon-yellow, green, blue, blue-violet and violet, but no red rays. This absence of the red rays makes it a very noticeable light and produces ghastly effects upon the human countenance when viewed by it. One, however, ceases to notice this effect after a short time, and the absence of the red makes it an exceedingly restful and desirable light for drafting rooms and fine mechanical pursuits. The light is very rich in actinic rays and it is the property that makes it peculiarly valuable for photographic purposes.

Worcester, Mass. H. P. FAIRFIELD.

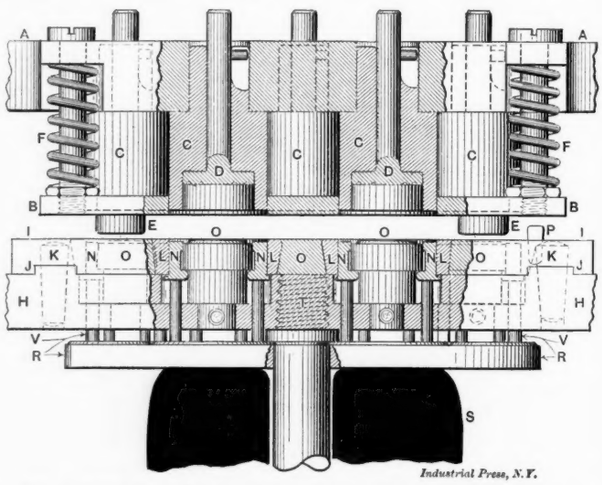
A "QUINTUPLE" COMBINATION DIE FOR PRODUCING FIVE DRAWN AND EMBOSSED TIN SHELLS IN ONE OPERATION.

Editor MACHINERY:

The development of the art of sheet metal-working and the improvements made in the tools used have been so rapid during the last few years that only those who are directly engaged along these lines have been able to keep pace with the construction of the tools used in such work. Thus, we find that tools which yesterday were thought to represent the height of perfection, in regard to longevity and production, are to-day obsolete because of others having been designed and put in successful operation for accomplishing many times the work of the former.

Of all the different processes of sheet metal working, however, it is in the drawing and forming of decorated tin boxes that we find the greatest innovations being introduced in the tools for their production; and it is my purpose in this article to illustrate and describe a set of tools used for the production of decorated tin shells, which should prove interesting to many sheet-metal goods manufacturers and to all diemakers.

In Fig. 1 are shown front views of the upper and lower sections of what may be called a "quintuple combination die," but which should properly be named "a gang of combination dies." The tools were used for producing five shells, 1¼ inches in diameter by 7-16 inch deep, from decorated sheet



Industrial Press, N.Y.

Fig. 1. Front View of Quintuple Combination Die showing Assembled Construction.

tin in one operation, the work done including blanking, drawing and embossing. The principle of construction carried out in the tools is essentially the same as that found in the usual single-action combination drawing die, and no attempt will be made here to give a detailed description of the making of the various parts, as the proper practice is now well known to all who are interested in such work. A general description of the assembling of the parts and the work accomplished will suffice for all purposes and, in conjunction with the engravings, point out to the practical man how similar tools may be adopted for the production of work of the same nature

in like or even greater quantities. I can see no reason why the principle may not be further extended in tools to produce a greater number of shells than those shown here, if a press of suitable dimensions and of sufficient strength can be procured.

As stated before, Fig. 1 is a front view showing, in conjunction with other things, sectional views of the first row of punches and dies, so that their construction may be clearly understood. Fig. 2 is a plan of the punch, or upper section of the tools; Fig. 3, a plan of the die section; Fig. 4, details of the smaller or working parts of the punch section; and Fig. 5, details of the smaller or working parts of the die section; while Fig. 6 illustrates the manner in which the stock is fed and punched so as to secure the maximum number of shells from a sheet and the minimum of scrap or waste.

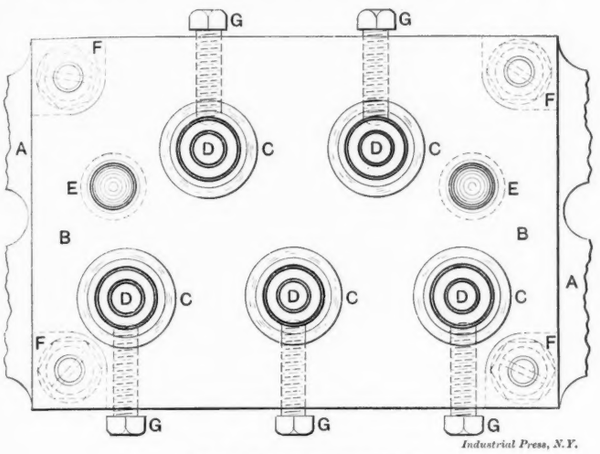


Fig. 2. Plan of Punch Section.

By taking Fig. 1 as the main reference drawings and referring occasionally to Figs. 2 and 3, the construction of the tools will be more easily understood. The positions of the details in the finished tools, Figs. 1, 2 and 3, may be determined by comparing the reference letters, which are identical in all drawings.

The lower or die section consists of, first, the main die plate *H H*, in which are located the five drawing and embossing punches *O, O, O, O, O*, the five blank holder rings *N, N, N, N, N*, the thirty spring barrel tension pins (six to each die), the spring barrel stud *T*, and five setscrews *Q, Q, Q, Q, Q*, for fastening the drawing and embossing punches.

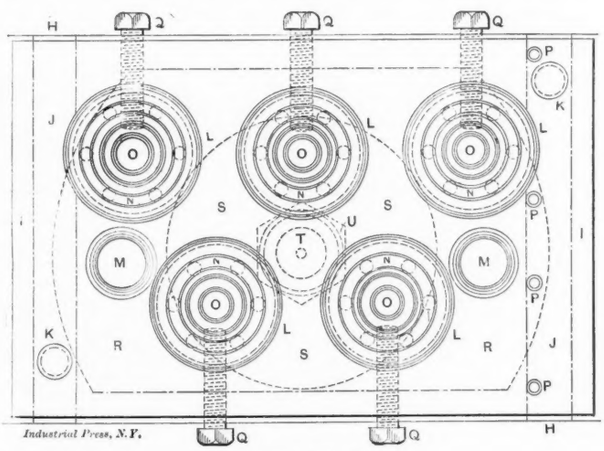


Fig. 3. Plan of Die Section.

Then we have the upper die plate *I I*, in which are contained the five cutting dies *L, L, L, L, L*, the two punch locating stud bushings *M M*, and the four stock gage pins *P, P, P, P*. The two die plates are of machine steel, and are located in alignment with each other by the two taper hardened dowels *K K*, and fastened by bolts at the ends, which are not shown. *R* is the upper spring buffer plate of cast iron, and *S* the rubber buffer. The machining and finishing of the seats for the various dies in the die plates necessitated some very accurate and careful work in order to assure alignment of the working parts.

In the upper or punch section, Fig. 1, we have, first, the holder, in which are contained the five combined cutting punches and drawing dies *C, C, C, C, C*, with their combined strippers and embossing pads *D, D, D, D, D*, the spring stripper *B B* for the stock, and the two punch locating studs *E E*, while *G, G, G, G, G*, Fig. 2, indicate the setscrews for fastening the punches within the holder. The holder is cast iron, while the stripper plate *B B* is machine steel. The combined cutting punches and drawing dies are of tool steel and were hardened, drawn and carefully lapped and ground, as were also the five combined strippers and embossing pads, *C, C*, etc. The locating studs were also accurately made.

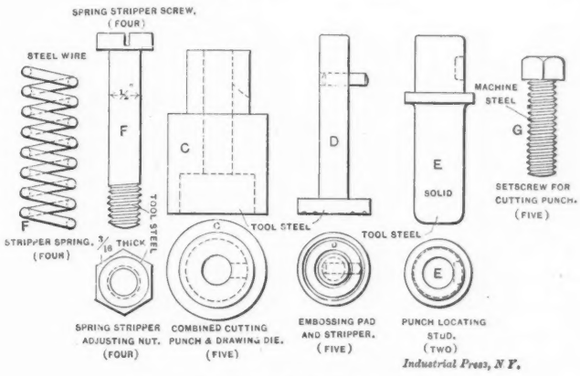


Fig. 4. Details of Small Parts of Punch.

It will be noticed that the two die plates *H H* and *I I* have their perfect alignment further assured by locating them by the tongues and grooves. The five cutting dies were forced into taper holes in the plate *J J*, while the five blank holder rings *N, N, N, N, N* were made so as to press up against the shoulders of the drawing punches *O, O*, etc., thus eliminating their tendency to work the cutting dies loose. The thirty spring buffer tension pins were of drill rod, and were accurately finished to size in length, being finished to within a limit of variation of one thousandth inch. Insignificant as they appear, these tension pins play a most important part in the proper working of a die of this kind, whether single or multiple in action. Unless they are finished accurately, so as to be of the same length, there is no possibility of drawing the metal uniformly, free from wrinkles, or without marring the decorations, through the unequal pressure which will be communicated to the blank holder rings by the inaccurately made tension pins. The manner in which the tools are used and the shells produced will be understood from the following:

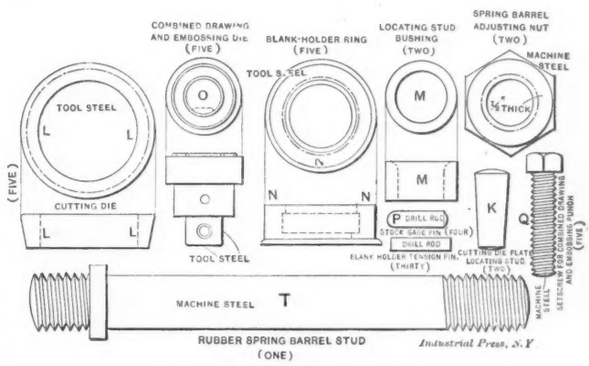


Fig 5. Details of Small Parts of Die.

Both sections are set up in an inclinable power press which is furnished with a two-bar knockout in the slide, so as to actuate the stripping and embossing pads *D, D*, etc., in the punches. The punch section is fastened to the press ram by bolts, and the die section to the press bolster by large cap screws. I might state that the press in which the tools were used is very powerfully geared and weighs about 3,500 pounds. It has a standard stroke of 2 inches, a maximum stroke of

3½ inches, and a circular opening in the bolster 13 inches in diameter. Both sections of the die were located in alignment by lowering the press slide and entering the two locating studs *E E* into the bushings *M M*. Then the stroke was adjusted, the spring buffer pressure regulated, and the work was ready to proceed.

The press being inclined, the metal is fed from right to left, one edge resting against the gage pins *P, P, P, P*, and the end extending to the edge of the back row of (three) dies. The press, being stepped, the punch section descends and the stock stripper *B B* flattens and holds the stock securely on the

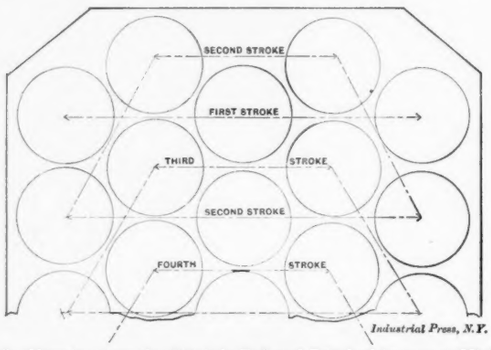


Fig. 6. Showing how the Stock is Fed and Punched to secure Minimum of Scrap or Waste.

face of *J J* while the blanks are being cut into the cutting dies *N, N*, etc., and drawn up into the cutting punch and embossed. As the slide rises the stripper *B B* sheds the stock from the punches, and the double bar knockout in the press slide actuates the five stripping and embossing pads *D, D*, etc., causing them to descend and strip the finished shells from the punches, when they drop to the die face and fall off at the back by gravity.

When it is realized that the product of the tools shown here was equal to five times the work of a single combination die, their output in a day of ten hours can be imagined, and the saving in labor and expense appreciated. Is it any wonder, then, that, not counting the cost of material, circular decorated and embossed shells of the dimensions here given can be furnished the consumer at the rate of 2 cents per 100, and in some instances, when the quantity ordered is well up in the millions, at even a lower rate?

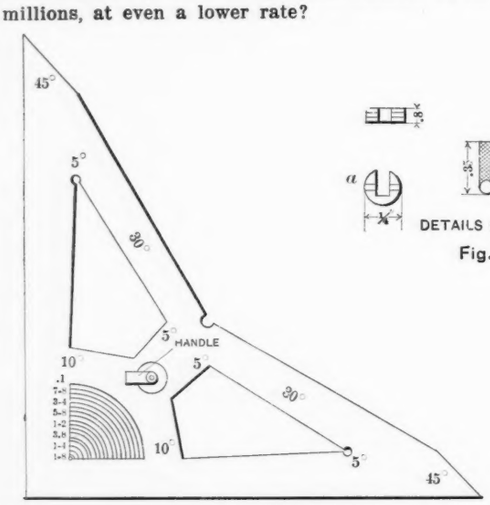


Fig. 1

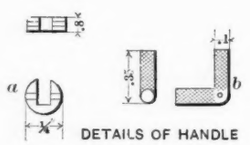


Fig. 2

CONVENIENT TRIANGLES FOR DRAFTSMEN.

Editor MACHINERY:

We of this generation and of the drafting profession are accustomed to think of ourselves as being particularly open-minded and hospitable to new ideas, but the coaxing sometimes required to get us to adopt new and almost obviously good things, does not always confirm this flattering view of ourselves. Many of your readers will, no doubt, recognize the triangles shown in Figs. 1 and 3 as being time-savers, but the idea is not new. However, I have never seen them described in print, although I have been using them for a number of years. On many details no previous laying off and penciling is required; the inking can be done rapidly and at once.

The 6-inch triangle shown in Fig. 1 is made of celluloid, thereby giving it the advantage of transparency. In the left-hand corner a hole is drilled with a No. 60 drill, and 90-degree arcs are drawn with it as a center, at distances 1-16 inch apart up to 1 inch radius. When a center is to be located at a certain radius, say, for a fillet joining two lines at right angles, place the triangle so that the ends of the arc of the required radius coincide with the lines and then with transfer-plug locate the center.

The triangle has a combination cut in it which will be found very handy in hurry-up jobs and drawing details such as wood screws, section lines, right- and left-hand screws, threads, etc. In the center is placed a small reversible handle, which is shown in detail in Fig. 2. It is made of German silver and the part *a* is driven into a hole bored in the celluloid. The notch in *a* is extended into the celluloid so as to afford space for one handle to lie in the plane of the protractor while the other projects upward. The triangle can be picked up from either side with this handle without the bother of unscrewing and screwing in, as we are accustomed to with the ordinary form.

The triangle shown in Fig. 3 is made of sheet steel, and is nickel-plated. A space is cut out on both sides and 3-inch scales are laid off on the beveled inner edges. The beveling is on side only, of course. One scale is laid off in 1-16 inch divisions and the other in 1-50 inch divisions. In the lower left-hand corner a space is cut out giving a scale exactly 1 inch long. This will be found most convenient for laying off center lines, sizes and heads for some kinds of screws, etc. The other angles come in very handy for every day use.

New Haven, Conn. A. L. MONRAD.

THE DETERMINATION OF RISES, CHORDS, AND RADII OF CIRCULAR ARCS FROM THE CO-ORDINATES OF A CURVE.

Editor MACHINERY:

It frequently happens that a draftsman or a mechanic has to determine or lay out the radius of a circular arc when the rise and chord are given. Templets in structural work, window and door centers, and circular crowns on pulleys are familiar examples.

Substituting in an equation involving the square of the

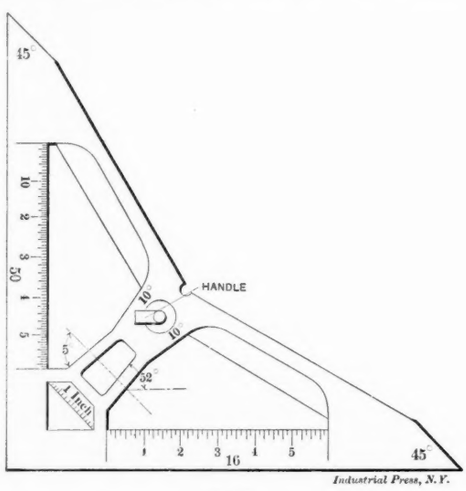


Fig. 3.

chord and the sum of two fractions, or consuming valuable time in making a geometrical construction to a reduced scale is the usual procedure.

The object of the diagram shown is to lessen the labor which is usually experienced in finding the radius of a crown when the rise and chord or base are given. The use of the curve is illustrated by the following example: Determine the radius of an arch whose rise and base are 7½ inches and 100 inches respectively. 7.5 ÷ 100 = .075, which is the rise for one inch width of chord; following the horizontal line passing through .075, we note that the reading at the foot of the ver-

tical line passing through the intersection of the horizontal line and the curve is 1.70; then $1.70 \times 100 = 170$, which is the desired radius. If other ordinates are desired besides the given rise they are as easily found from the curve by taking convenient and shorter lengths of chords with the same radius and subtracting from the given rise.

With some manufacturers of pulleys it is frequently the rule that the curved crown is always a constant fractional part of the width. When that is the case it is only necessary to multiply the proper reading at the vertical by the width of the face; as, for example: If the crown is always one-tenth the width of the face and the face is 6 inches, then the radius of the crown is the corresponding co-ordinate $1.3 \times 6 = 7.8$.

It is obvious that when any two of the factors are given the third is readily found. Readings from the curve are easily taken within one-half of one per cent. of accuracy. Absolute accuracy, which is rare and usually impracticable, can only be obtained by substitution and computation in a long formula.

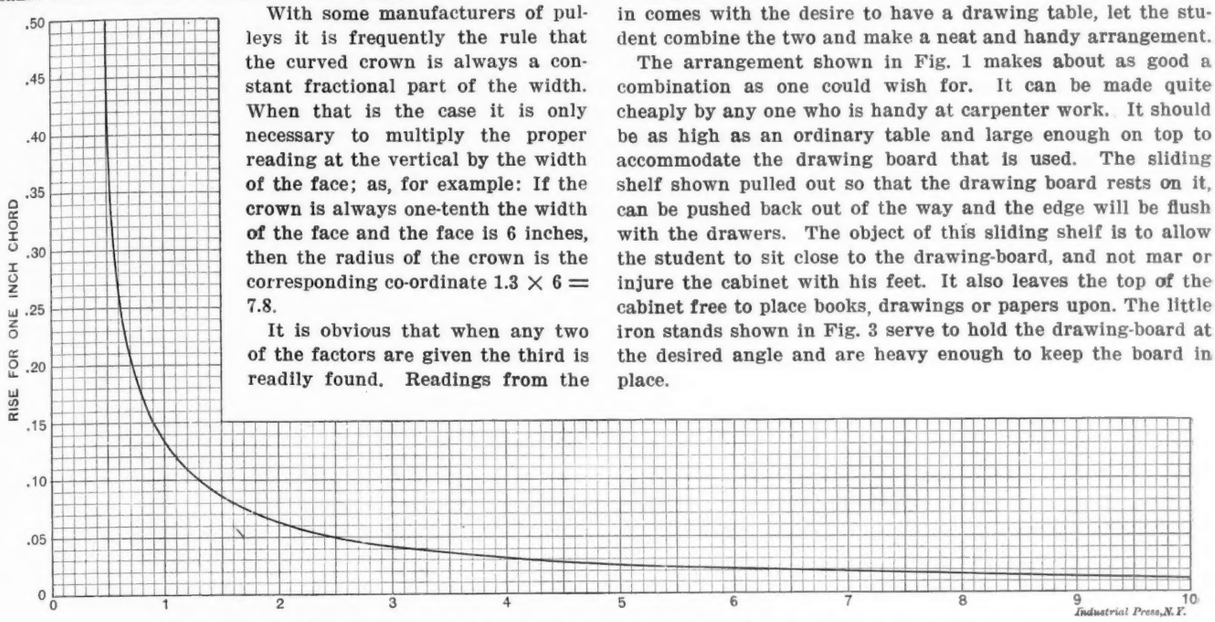


Diagram for Graphical Determination of Rises, Chords, and Radii of Circular Arcs from Co-ordinates of a Curve.

Ithaca, N. Y. C. E. COOLIDGE.

A HANDY DRAWING CABINET FOR HOME USE.

Editor MACHINERY:

Drawing or drafting during spare evenings at home, has become quite a common occupation for young men of ambition whose minds are turned in a mechanical direction. The usual outfit to start with, is a drawing-board, T-square and triangles, with a cheap set of drawing instruments, using the kitchen table as a base of operations. Every time the student wishes to do some drawing he is obliged to go to a closet or pantry, take out his "kit" and distribute it over the table before he can begin work, and it usually happens that he will be obliged to hunt up two or three articles he has forgotten before he is finally ready for work. Then when he is through he is obliged to pack up his kit in as small a space as possible and put the instruments back where they are kept. After a while this sort of proceeding becomes monotonous and the student desires something handier, so he starts in to devise some style of drawing table. By the time the student feels the need of a drawing table he has quite a collection of drawings on hand that need a place where they can be kept handy and in good condition. Now as the need of a cabinet to keep his drawings in comes with the desire to have a drawing table, let the student combine the two and make a neat and handy arrangement.

Fig. 1. Drawing Cabinet for Home Use.

The arrangement shown in Fig. 1 makes about as good a combination as one could wish for. It can be made quite cheaply by any one who is handy at carpenter work. It should be as high as an ordinary table and large enough on top to accommodate the drawing board that is used. The sliding shelf shown pulled out so that the drawing board rests on it, can be pushed back out of the way and the edge will be flush with the drawers. The object of this sliding shelf is to allow the student to sit close to the drawing-board, and not mar or injure the cabinet with his feet. It also leaves the top of the cabinet free to place books, drawings or papers upon. The little iron stands shown in Fig. 3 serve to hold the drawing-board at the desired angle and are heavy enough to keep the board in place.

The two upper drawers can be used for drawing instruments, pencils, and any miscellaneous articles that may be desired for use. By placing the drawer that holds the ink and instruments on a chair by the side of the student they will be handy for use.

It is convenient to have two sizes of drawers and two sizes are shown in Fig. 1. One of the small drawers is shown in Fig. 2. All of them will be better if not made too deep. The best depth is about 2½ inches. A board about 12 inches wide and 3-16 inch thick placed on the top and back of the drawer will aid in keeping the drawings flat and in good condition. The drawers can be numbered by placing a properly marked index card in the slot shown above the handle of each, and the drawings can be so arranged that each one can be found readily and without injury to the others.

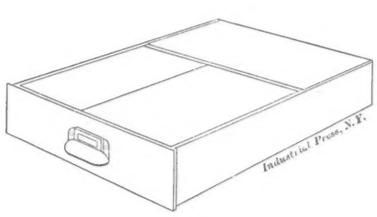


Fig. 2.

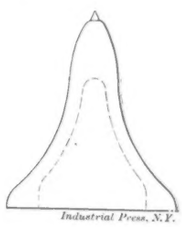


Fig. 3.

With a cabinet of this construction it will take a moment for the student to take out the drawer containing the instruments, pull out the sliding shelf, place the drawing-board upon it and he is ready for work. When he has finished work it will take but a moment to place the different articles in readiness for the next evening's work, and he always knows that anything he needs in his work is at hand. F. W. A.

* * *

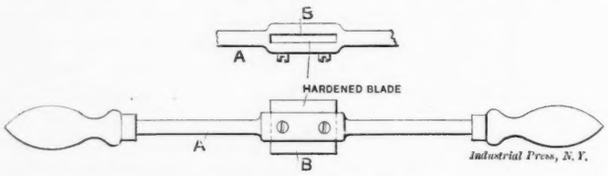
An English firm, Drake & Gorham, Westminster, London, are exploiting a magnetic clutch designed to supersede countershafts in shops. The cone pulley is mounted directly on the lineshaft and is made to rotate with it when the machine is running by means of the magnetic clutch which, of course, is energized by an electric current, under control of the operator. It is claimed that noise is reduced, that a large saving in power is effected by its use and that shop lighting is much better because of the absence of countershafts.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP
Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

HANDY SCRAPER FOR BOXES.

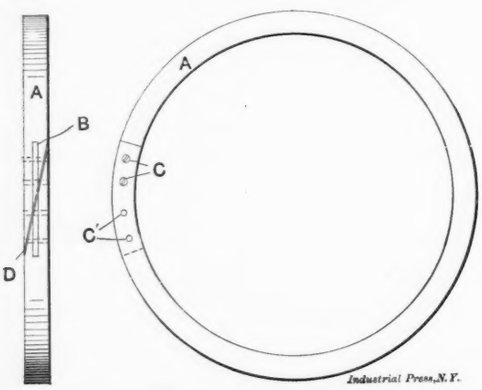
The sketch shows a scraper having two handles, which was recently seen in use in the shop of Schumacher & Boye, Cincinnati, O., scraping out lathe headstock boxes. The tool consists of a forging, *A*, having handles fixed on the ends, and a slot put through the enlarged center part. In this slot is fixed the cutter blade, *B*, held in place by two screws. The advantage of this construction over that of the single-handle side-



cutting scraper, is that the tool can be grasped with both hands, thus making the work easier where it is possible to attack it in the way it is done on lathe headstocks, that is, with a hand on each side of the box. The blade is a comparatively small piece of steel which makes it feasible to have quite a number of blades for the same stock, if desired.

METHOD OF MAKING RINGS FOR SELF-OILING BEARINGS.

An electrical manufacturing concern has an interesting method of making rings for self-oiling bearings, especially those for large generators. The ring *A* is made of brass or bronze, cast in one piece without joint. After it has been bored, faced and turned, a slot *B* is milled or sawed lengthwise through the ring. In this slot a piece is closely fitted to fill the space. Then four holes, *C C* and *C′ C′*, are drilled and



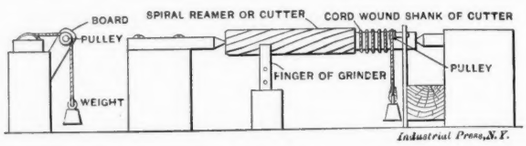
tapped for screws. Two of the screws are put through from one side, and the other two from the opposite side. The piece *B* is then removed and a diagonal cut *D* is made, dividing the ring so that it can be sprung over the shaft. Then the tongue piece *B* and the screws are assembled. The advantage of this method is that the shape of the ring when assembled is not distorted, it being left exactly the same diameter all around.

DRILLING HARDENED STEEL PLATES.

It is a common thing to draw the temper of a tool or other piece of steel on the emery wheel, but this has usually a detrimental effect and one that has to be guarded against rather than to be sought after. "F. J. K.," however, sends us an account of how he was able to overcome considerable trouble by this principle. Having ordered a dozen 15 x ⅛-inch circular saw blades for a Newton cold saw, an omission in the order caused them to be delivered without the six holes that are usually provided for the reception of the driving pins. An attempt was made to use them as they were but this was found impossible; so it became necessary to find some method of drilling the holes in the hardened steel plates. After every trick known to the trade had been tried, one of the holes was marked out in the place where it was to come and the saw blade at just this point was applied to the surface of a rapidly revolving, fine, glazed emery wheel and held in this position for a few moments. This so effectually drew the temper that the hole was drilled without any difficulty and this way the saws were made available for use.

FIXTURE FOR GRINDING SPIRAL CUTTERS.

The sketch shows a handy attachment for grinding spiral cutters or reamers; in fact it will be found a great help in keeping any kind of cutter down to the finger rest. The idea is not original with me, but never having seen anything like it in use, I thought it might interest the readers who use



cutter grinders. A cord is wound around the shank of the cutter or arbor and carried over a small pulley which, in this case, was attached to a board clamped to the slide. A weight at the end of the cord holds the blade down against the finger rest of the grinder. It will be found to save your temper as well as that of the cutter.

K. C. B.

EXPANDING LEAD LAP.

The sketch shows an expanding lead lap that I have used for many years with great satisfaction. As evident from the cut it simply consists of the taper steel mandrel, *A*, in which a groove *C* is cut the length of the tapered part, and on which

is mounted the lead sleeve *B*. Driving the arbor into the sleeve enlarges it and keeps it round and straight. I have used several kinds of lead laps but this is the best of all.

Assonet, Mass. B. F. AIKEN.

NUTS USED AS CHUCKS ON LATHE CENTERS.

I have a shop kink which has served me so well in my work on a lathe that I desire others to have the benefit of it. It is this: Take the lathe centers and cut a thread on the large end according to size—say for one-inch nut (that is the size of my 16-inch swing lathe). The nut serves to pull the center out, and the center is always ready to face any nuts of that size. Extra nuts are used to make all kinds of chucks by turning the nut to fit and driving it hard into the work, leaving ¼ inch on the nut for the wrench. This method saves taking out the centers and removing the faceplate. I have numerous nuts always ready, requiring no change.

Plainfield, N. J. HIRAM A. MEARS.

REPAIR OF ROCKER ARM.

Some time ago a rocker arm came to our shop to be babbitted and changed somewhat in construction. The casting was bored and babbitted without any means being provided for taking up lost motion. Fig. 1, on next page, is a side view. The part at *a* was bored and babbitted for the pin on the engine and as it was a solid box, the owners wanted it fixed so that all lost motion could be taken up as the bearing wore down. To do this we cut out sections at *b b′* and fitted other pieces in their places so as to adjust radially. As indicated in Fig. 2, the casting was 1¼ inch thick around the bore, and 4½ inches in diameter. After the pieces *b b′* were fitted snugly in place, bands *c c′*, 9-16 x 1½ inch, were shrunk around both ends to stiffen the castings and to hold the setscrews *d d′*, which were provided to set up the movable pieces *b b′*.

What seemed a strange feature of the job to us was the fact that after the bands were shrunk on, the slots were closed in fully 1-32 inch, which made necessary the refitting of the

pieces *b b'*. We allowed 1-16 inch shrinkage for the bands, but had no idea that such a thick rigid casting would be so distorted by shrinking on the bands. This feature of the job reminded me of another job that I witnessed some time ago. A water jacket was shrunk around the cylinder of a gasoline engine. The engine was all finished except the jacket, which

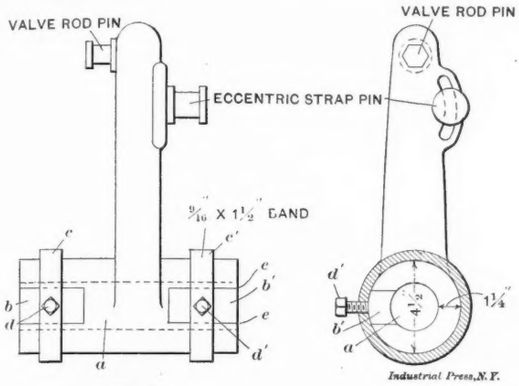


Fig. 1.

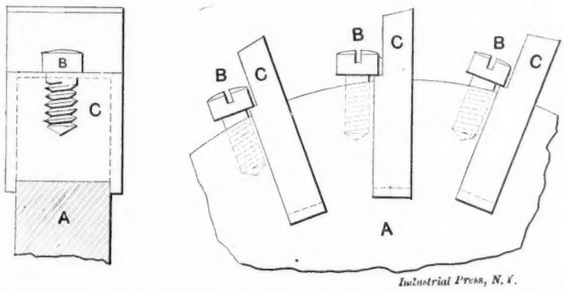
Fig. 2.

was a piece of 8-inch pipe. After the pipe was shrunk on it was found that the jacket had contracted the cylinder to such an extent that it was necessary to turn down the piston before it would enter the bore. N. G. B.

Muscatine, Iowa.

INSERTED-TOOTH MILLING CUTTER.

F. E. R. submits a sketch of an old form of inserted-tooth milling cutter used extensively by at least one New England concern, the Armstrong Mfg. Co. The body of the cutter, *A*, is of cast iron and is slotted for the teeth in the usual manner. The cutters, *C*, *C*, *C*, etc., are made of Howe-Brown steel

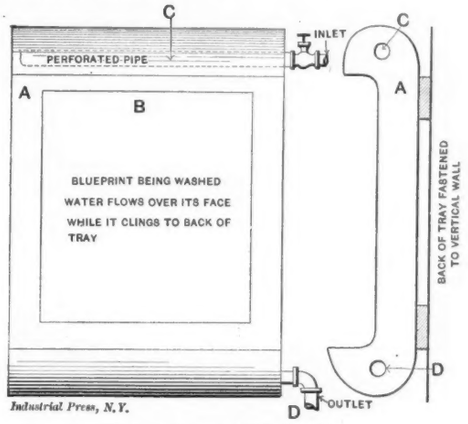


in this case, and are shouldered for engagement with the screws, *B*, *B*, *B*, etc. The inner ends of the cutters are notched, as shown in the cross-section, to engage the sides of the body and prevent side slip. These cutters work well, are simple to make, and may be used for either radial or end cutting.

VERTICAL BLUEPRINT WASHING TRAY.

The sketch shows front and end views of a blueprint washing tray used in the drafting room of the King Machine Tool Co., Cincinnati, O., which we would designate as a novelty were it not that it has been used too long for that, at least one other concern having used the same thing for several years. Nevertheless, it is of interest and value, being one of those contrivances that, for some reason or other, has never "caught on," although possessed of considerable merit. It takes up but little room, being fastened to the wall in a vertical position; it is automatic in operation, and the cost is low.

The tray, *A*, is made of galvanized iron so shaped that a hood is formed at the top and a trough at the bottom. The sides are carried to a height of say, 1½ or 2 inches. A pipe, *C*, is carried transversely under the hood, which is perforated on the back side with a row of small holes. The water is thus directed against the back of the tray, where it flows in a thin sheet down over its face into the trough where it escapes at the outlet, *D*. A blueprint to be washed is merely placed against the back of the tray where it clings by the virtue of its "stick-to-itiveness" while the water courses down over its face, washing it thoroughly, and as long as desired without attention.



Vertical Blueprint Washing Tray.

* * *

A REVERSIBLE TAPPING MACHINE.

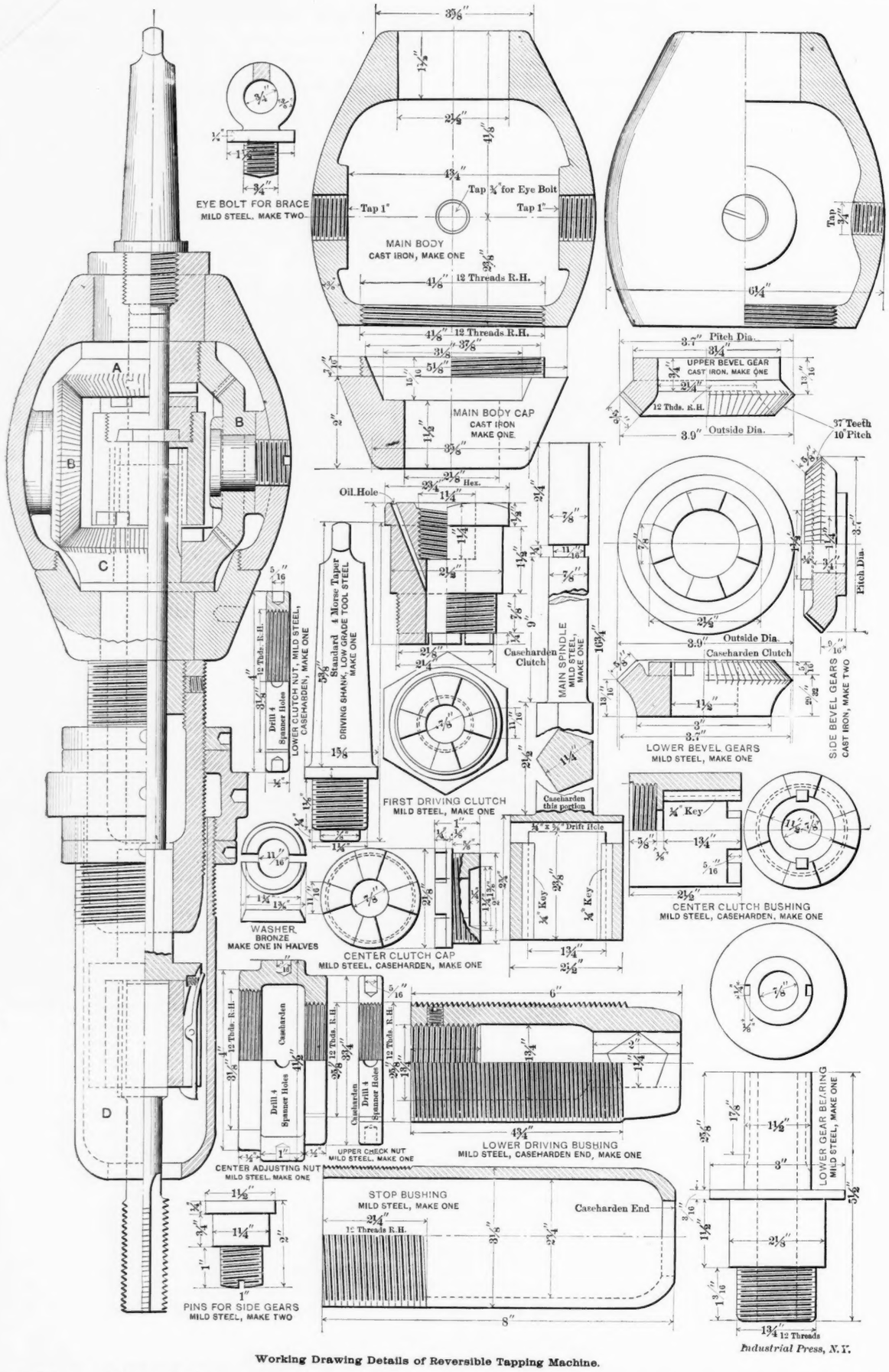
Mr. Fred Harrison, Philadelphia, Pa., has furnished us with the details of the tapping mechanism that is shown on the next page which possesses quite a remarkable record for a mechanism of this kind. It is in use in the Cramp ship yard for tapping condenser sheets and similar work, and in the course of the eighteen years that it has been in service it has tapped about all of the sheets on every vessel that Cramp has made for the United States Government and many others. In all it has tapped over 1,000,000 holes and is still in first-class order.

The device is not as handy for setting to tap a few holes as many of the more modern devices that are now on the market, but for tapping hundreds of holes without changing it has been found to stand up to the work, day and night, as no other device that has been tried. Although rather heavy, it is provided with a brace to suit the machine upon which it is used and is nicely counterbalanced, two eye-bolts being inserted in the sides to provide for attaching the counterbalance.

The working mechanism of the device will be clearly seen by reference to the semi-sectional assembled view that is given at the left of the details. The taps are held in bushings in the end of the main spindle, the capacity of the machine allowing the use of taps ¾-inch up to 1½-inch. The driving shank, of standard Morse taper, fits the socket of the drill press and drives the upper bevel gear *A*, and then, through the medium of the side bevel gears, *B B*, drives the lower bevel gear *C* in a direction opposite to that of the drill spindle. With the main spindle in the position shown, no movement of the tap takes place, but as the device is lowered, the tap encounters the work and causes the spindle to push back the center clutch so that its upper jaws come into mesh with the jaws on the upper driving clutch, and the tap is driven into the work, rotating with the spindle of the drill. The stop bushing *D* is previously set to suit the depth of the hole required, and when the nose of this bushing strikes the work further descent of the device is prevented, so that the tap at once draws down the center clutch out of mesh with the upper driving bushing and thus comes to a stop. The device is now raised for withdrawal and a slight upward movement causes the center clutch to engage with the lower bevel gear and thus rotate the tap in a backward direction.

As will be noticed in following out the details, the tap is not at any time driven through the spindle, but through the bevel gear bushing and the driving bushing, both of which are of large diameter, and thus give a strong and positive drive. All of the gears are in continuous operation so that no stopping of the drill press is necessary; but the mechanism is of such a nature that the tap is brought to a full stop before the reversing parts are thrown into action, so that the tap meets with but little strain on the reversal.

With a ⅛-inch saw, the lower driving bushing is split on



Working Drawing Details of Reversible Tapping Machine.

Industrial Press, N.Y.

the five points to within one-half inch of the end. It is then adjusted with the lock nut to suit the strain of the tap so that in case of accident the tap will be free to revolve.

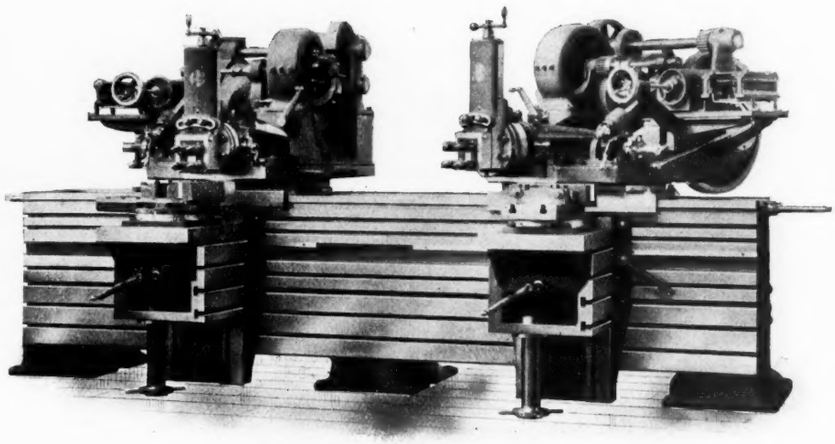
In view of the success with which this device has been used we have reproduced the details in full in order that anyone so desiring can make one for himself.

NEW TOOLS OF THE MONTH.

A RECORD OF NEW TOOLS AND APPLIANCES FOR MACHINE SHOP USE.

DOUBLE-HEAD TRAVERSE SHAPER.

This machine has been designed for machining at one time the two ends of steel beams, or similar work, at angles of from 45 to 90 degrees. The makers call attention to the swiveling saddle, which, they say, is a distinctly new feature. As will be seen, each head is driven by an individual motor. Each of these motors not only operates the ram, but all feeds as well; that is, longitudinal feed to saddle, slow for cutting and fast for traversing, and the power feed to the head, which may be vertical or at any desired angle. There is also a hand traversing feed to the saddles, through the longitudinal screws. There is a hand feed to the head, and a rotary hand feed to the heads, by means of the crank wrench, shown on the right-hand head, through worm and worm gear.



Cincinnati Double-head Traverse Shaper with Motors on Saddles.

The motors and the controllers for operating them are carried on brackets bolted directly on the saddles, and as all feeds are operated from the saddle, the workman, with the controller thus located, has full control over the machine from this one position.

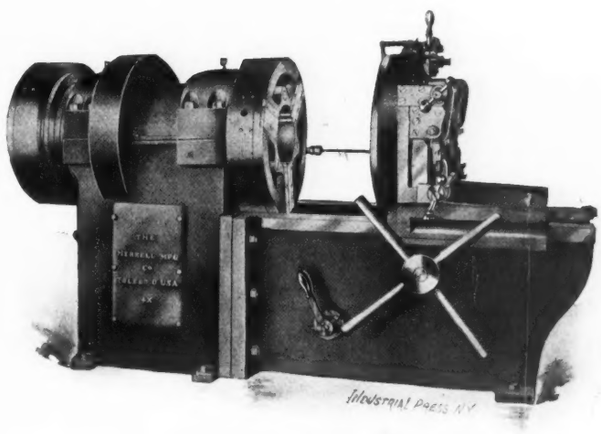
The rams being operated by the well-known Whitworth motion have a quick return. The longitudinal feeds, both slow cutting and fast traversing, are obtained through systems of gearing operating nuts which engage on the longitudinal screws, a system of bevel gears transmitting the motion from the swiveling saddle to the traversing saddle.

The motors are each 5 horse power, of the Crocker-Wheeler, multiple voltage, 3-wire system type. The machine shown is 24 inches by 14 feet and weighs 27,500 pounds net. It is built by the Cincinnati Shaper Company, Cincinnati, Ohio.

PIPE CUTTER AND THREADER FOR HEAVY WORK.

The accompanying half-tone illustrates the design of the "Apex" machine for handling large sizes of pipe. It is manufactured by the Merrell Mfg. Co., Toledo, O. The head column is cast in one piece and an apron is bolted to it. This allows both column and apron to be supported at every point by the floor. The machine is so geared that a separate speed can be obtained for each size of pipe within the range of the machine. The gearing is entirely inclosed within the head column of the machine, is out of the way of the operator and protected from dust and chips. The speed is entirely within the control of the operator, who, moving the lever shown on the front of the apron bed, can change his speed while the machine is in motion, permitting same to thread at one speed and cut off at another. The chucks on both the front and rear of the machine are the same. Projecting jaws are furnished to permit of holding flanges for making up pipe. The chucks are powerful universal chucks, making it unnecessary to tighten each jaw separately; tightening of one jaw centers the pipe and grips it firmly. The head is very massive and the dies are controlled by means of a hand lever attached to a pinion engaging the cam ring which in turn engages the dies. The movement of the hand lever engages or disengages the chasers from the pipe. In setting the dies it is only necessary to loosen the lever from the cam ring pinion and turn the cam ring pinion until the cam adjusts the dies to the size of pipe it is desired to thread, then to tighten the nut on the hand lever.

The head can be moved out of the way of the cutting-off tools, to allow cutting close up to the chuck. The cutting-off blades are two in number, cutting from both sides of the pipe at the same time, saving over one-half the time in cutting off pipe. The use of the geared cam ring, and pinion to operate same, is quite novel and allows of the opening of the dies when engaged in threading without forcing the dies on the pipe as is customary with machines using the toggle-joint locking device. The chasers are very heavy and of unusual width, allowing a proper taper to be obtained for the full length of a standard thread.



Pipe Threader and Cutter for Heavy Work.

SIXTEEN-INCH BACK-GEARED CRANK SHAPER.

The illustration herewith is of a 16-inch crank shaper built for heavy cutting. The column contains bored seats for the journal boxes of the driving mechanism. The flanged sleeve, which forms a bearing for the crank gear, is fitted with a reinforced section of the column to insure steadiness under heaviest cuts. The top of column extends beyond the face on each end to provide long bearing surfaces for the ram. The surface to which the cross rail is clamped is very wide and deep, giving rigid support to same.

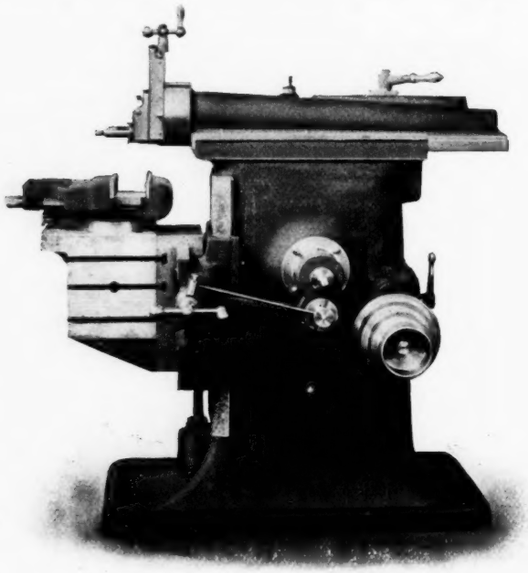
The ram is of semi-circular section—long, wide and deep, and may be adjusted to suit the work while in motion. The tool head has graduated swivel adjustable to any angle, and is securely clamped to ram by two bolts. The down-feed screw is provided with micrometer collar and is furnished with automatic feed, if desired.

The cross rail has a long bearing on column and is made of extra depth and unusually heavy. It is elevated by means of a screw with ball-bearing thrust. The cross feed screw has

power feed in either direction and is fitted with micrometer collar.

The cross slide is furnished with gibs, which may be adjusted to prevent lost motion. The box table is secured to cross slide by two studs and one bolt. The studs are screwed in the table near its upper surface and pass through the cross slide at points where it is subjected to the pressure of the cut, relieving this casting of tension strain. The vise may be bolted either to top or sides of table and is fitted with steel faced jaws and a graduated circular base-plate. An index pin is provided to lock the vise when same is set parallel or at right angles with ram. The cross rail, cross slide and table are very deep, which insures rigidity and obviates the necessity for extra support, saving the time required to adjust such a support.

The driving mechanism is arranged for two speeds, which, in connection with the four-step cone for wide belt, gives eight speeds in geometrical progression. The driving shafts are journaled in ring oiling bearings and have large gears with wide faces, which are controlled by lever at the rear of column. Provision is made so that both sets of gears cannot



Sixteen-inch Shaper.

be engaged at the same time. The stroke of ram can be varied while the machine is in motion or at rest, by means of a heavy wrist block. The countershaft is fitted with self-oiling boxes and tight and loose pulleys. Following are the principal dimensions of this machine: Maximum stroke, 17 inches; vertical adjustment of table, 15 inches; cross motion of table, 20 inches; tool block feeding in any direction, 6 inches; vise opens 8 inches. The shaper is built by the Springfield Machine Tool Co., Springfield, Ohio.

MULTIPLE-SPINDLE GANG DRILL.

The gang drill shown in the half-tone herewith is the latest production of the Moline Tool Co., Moline, Ill. It is made in any length of rail. The one here shown is 7 feet long and with ten heads, the regular heads adjusting to within 2¼ inches of one another to centers of spindles. This size of machine is built for ½-inch drills. Spiral gears, meshing into continuous spirals set in the rail, drive the spindles; and a head may be set in any place or adjusted to any position along the rail without interfering with the drive.

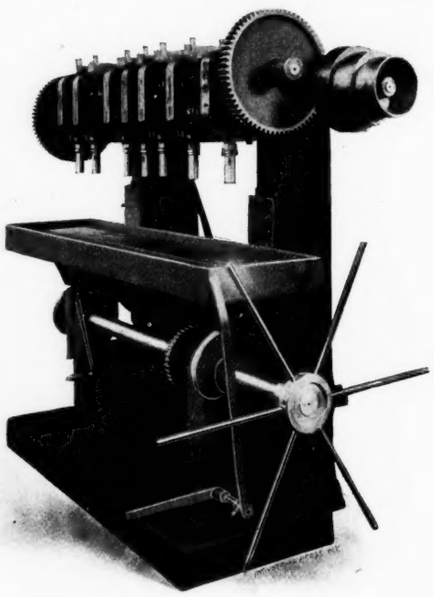
The rail and housings are of box form, and heads are fitted to one V-way and one flat way, making them easy to fit and to keep in line.

The machine is powerfully geared with three changes of speed and three of feed. The table is fed upward by cams; the shaft is driven by worm gearing which can be thrown out at any point when it is desired to operate the table by hand. The cam feed has a quick return and an automatic stop, and the feed can be thrown in either by the hand lever shown or by the foot.

The table has a vertical adjustment of 4 inches, is counterbalanced and has a wide and deep groove for the oil. The spindles have a vertical adjustment of 2 inches, to permit of the use of different lengths of drills. The base of the machine is made in the form of an oil pan. The 7-foot machine here described weighs about 5,000 pounds.

IMPROVED HYDRAULIC SHEAR.

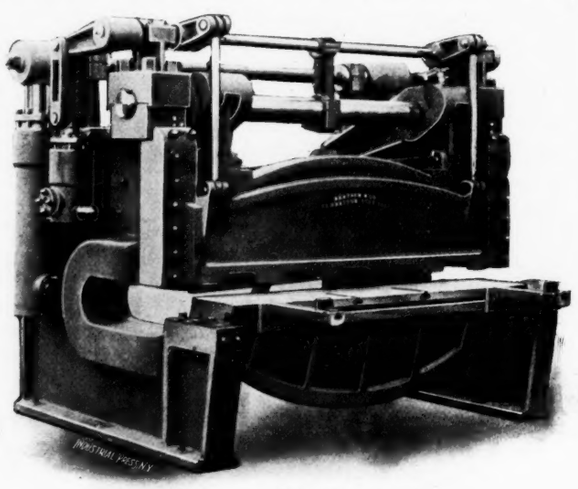
We illustrate herewith a hydraulic shear manufactured by Bertsch & Co., Cambridge City, Ind., for cutting ¾-inch plates. This is 10 feet in length, with a 30-inch throat. It has a cylinder in each housing with the rams connected directly to the rock shaft by levers. The cylinders are so connected and



Multiple Spindle Drill.

water so governed that pressure in both cylinders is equal. Pressure in the two cylinders is equal when cutting, owing to the manner in which the cylinders are connected and the water is regulated. Other shears for lighter work are built, having but one cylinder. The advantages of a hydraulic shear are that it can be stopped, started or reversed at any part of the cut. The liability to break from lapping of the blades or the introduction of metal of too great thickness is obviated by the castings and connections being made very strong, so that they will withstand a strain greater than the maximum attainable from the cylinders; consequently, the shear will simply choke and stop without any damage to it.

The cylinders take water in one end, and it is cut off the instant the stroke is made. The knife bar or cross-head and



Improved Hydraulic Shear.

hold-down return by gravity. No water is required to hold them in position when not in motion. No water is used except when actually cutting. The hold-down is operated automatically and adjusts itself to any thickness of metal.

Where factories are not supplied with hydraulic pressure a pump is furnished with the machine and arranged for the continuous use of a small amount of water or oil.

This machine is made any length from 6 to 14 feet, with any depth of throat from 18 to 36 inches, for plates of any thickness from ½ inch to 1½ inches, varying accordingly in weight from 30,000 to 150,000 pounds.

IMPROVED RADIAL DRILL.

Fig. 1 is from a photograph of one size of the line of radial drills made by the Hamilton Machine Tool Co., Hamilton, O. These drills are built in sizes from 2½ to 5-foot arm, and are equipped with various styles of tables, swiveling or otherwise, in addition to the bedplate. Recent improvements have been made in these drills, among which is the geared power feed shown in Fig. 2, which possesses novel features.

The changes in feed are produced by two sets of gears, one of which is the nest of three gears *C*, arranged in a cone, and the other the back gears *E*. These gears are driven directly from the spindle and operated by means of two small levers shown beneath. An attractive point in the arrangement is that the feeds can be easily changed at any time, no matter whether the machine is stopped or in operation.

In feed mechanisms of this description it has been customary to slot the cone gear shaft and to have a sliding feather to throw the different gears into action. This weakens the

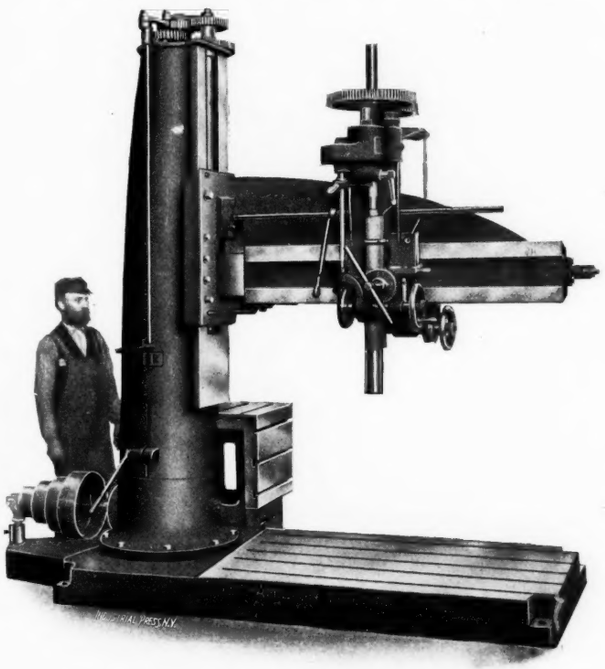


Fig. 1. Radial Drill made by Hamilton Machine Tool Company.

shaft and in the present instance a departure has been made by arranging the whole shaft so that it will move through bearings at each end and carry the feather with it.

The sliding shaft *A*, contains a movable key *B*, the corners of which are beveled so as to readily pass the adjacent gears when changing from one to the other. By moving shaft *A*, key *B* can be engaged in any of the feed gears *C*, each of which is provided with four keyways. The spring pin *D* is placed so as to constantly exert a pressure on the key sufficient to force it into the keyway whenever the two are opposite. Feed gears *C* are separated by hardened steel collars, so that the key must entirely clear one gear before it can engage another. The shaft *A* is hardened and ground, ample facilities are provided for oiling, and the whole arrangement works smoothly and easily.

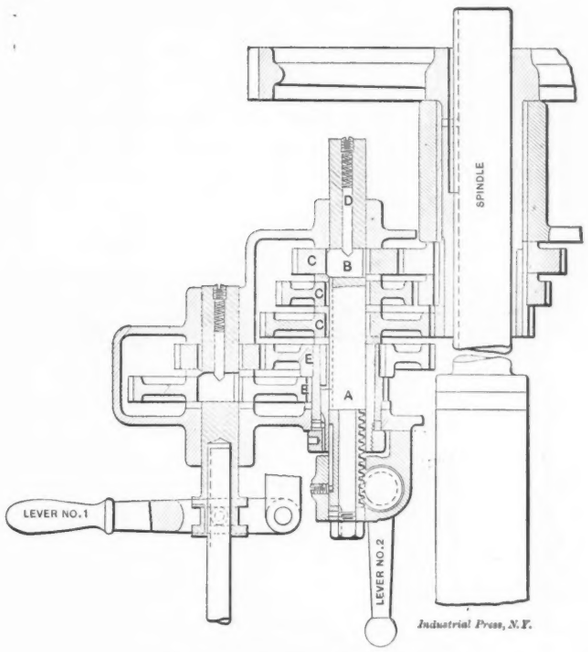


Fig. 2. Feed Mechanism of Radial Drill.

It will be seen that the lower feed gears *E* are friction-driven, the object being to afford a slipping point in case of severe strain, thereby preventing broken gears or more serious damage. The danger of breakage under heavy duty has always been a strong objection to direct-geared feeds, but the adoption of the friction safety release just mentioned, reduces this danger to a minimum. On the 5-foot size which is illustrated there are six feeds for each spindle speed, ranging from .005 to .062 inch.

ADJUSTABLE REAMERS.

Fig. 1 shows a patented universal adjustable reamer recently placed on the market by Schellenbach & Radcliffe, Cincinnati, O. There are three styles of these: The shell, the hand and the machine reamers. The body of the tool is of machinery steel, with taper slots milled to receive the blades, of tool steel. From six to twelve blades are inserted in each reamer and are unevenly spaced. These blades are adjusted by means of the threaded collar on the shank end of the reamer, Fig. 1. The adjusting collar has a groove turned on the inside of the front face of the collar, to receive the tongue milled on the end of the blades. Turning this collar moves all blades simultaneously. To adjust the reamer the binding screws on the blades are released about one quarter turn,

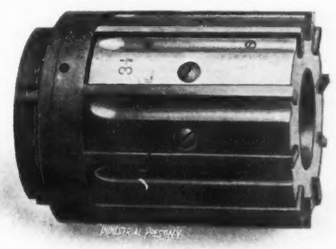


Fig. 1. New Adjustable Shell Reamer.

which permits free movement of the blades with a spanner wrench, which is furnished. Each blade is held in the body of the reamer independently. The lower front side of the blade has a groove milled parallel to its bottom, and the lower part of groove forms a ledge on the top of which the ends of the screws bear squarely, eliminating side strain on the screws.

In Fig. 2 is a roughing reamer, with high-speed steel cutters. The body is of machinery steel, milled to receive the cutters, whose front side, as in the case of the reamer blades, have a groove milled near the bottom and parallel to it,

the top of the groove furnishing a ledge upon which the screws seat themselves. The heel sides of the cutters are sufficiently relieved to clear themselves well. The tool is for use in cored work, where considerable stock is to be removed without preliminary boring. The ends of the cutters are ground square and will cut to their bottoms. Adjustment is provided for the end wear of the cutters by driving them forward from the shank end of the reamer.

Fig. 2. Adjustable Roughing Reamer.

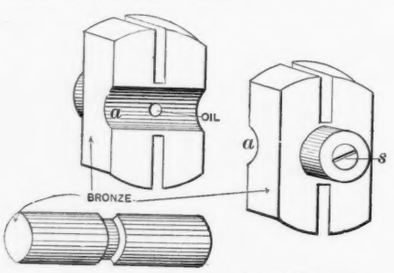
If started true, these reamers will make a round straight hole, even though the core be considerably out of true. Thus a 2-inch reamer will remove ¾ inch of stock at one cut. The cutters are interchangeable and are built for heavy, hard service. They are made in sizes from 1 inch to 12 inches in diameter, the larger sizes being made in shell form.

UNIVERSAL JOINT.

F. E. Bocorselski, of Springfield, Mass., the inventor of several universal joints, has recently brought out a new one, which is an improvement on the previous ones, and is extremely simple to assemble. This joint has the usual two-

Fig. 1 New Universal Joint of Simple Construction.

forked shaft connections, through which diametrically opposite holes are drilled for the usual pivoted joints. Instead of a solid transmission block, however, to form a connection between the two forked ends, the inventor has made this block in two sections, as shown in the detail sketch. These blocks are made of phosphorus bronze. Each is grooved at *a a*, to fit the pin shown, which passes through the holes drilled in one of the forked members. At the back of each



Industrial Press, N.Y.

Fig. 2. Details of Universal Joint.

of the blocks is a trunnion to fit one of the holes drilled in the other forked member.

In assembling the joint the blocks are first put in position between the jaws, the other fork is then slipped over the blocks and the pin is pushed through into place. This pin is grooved at the center for the point of a setscrew *s*, which passes longitudinally through one of the trunnions, thus locking it in position.

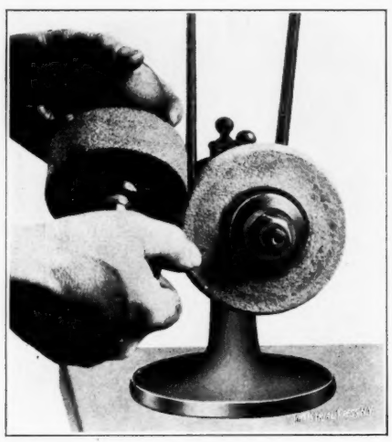
The strength of this or a similar type of universal joint rests ultimately in the capacity of the jaws to resist the tendency of the block to spring them apart under torsional strain. Therefore, a joint built in sections, like this one, has ample strength to transmit power, and has the advantage of easy assembling. The blocks are split, as shown, for the reception of felt, which retains the oil; and felt is also placed between the two blocks for the same purpose.

EMERY WHEEL DRESSER.

A novel emery wheel dresser in which an emery wheel is used in place of the usual diamond point or other device has been brought out by the Heald Machine Co., Worcester, Mass. It is known as the Metcalf emery wheel dresser, and the illustration shows the method of using it.

The device consists of two cast-iron balls at the ends of a short shaft, with an abrasive wheel mounted on a sleeve between them. The balls give weight, which assists in keeping the wheel up to its work, and are held in the hands when the dresser is in use. The success of the device depends upon: First, the inertia due to the weight of the balls; second, the peculiar cutting effect of one abrasive wheel on another when held at an angle of 30 to 40 degrees from the horizontal; and third, the fact that the cutting wheel has a gyroscopical action tending to hold it always in its own plane.

It is found that this dresser cuts out the bond or filling between the abrasive particles of the wheel and leaves the latter standing out on the surface in the best possible condition for rapid grinding. A special advantage is that by its



An Emery Wheel used for Truing an Emery Wheel.

use a sharp corner can be brought up on thin or delicate wheels, as it does not have a tendency to break off the corner. It is also of use in freshening up the face of a wheel when glazed over, even if it is not desired to true up the wheel.

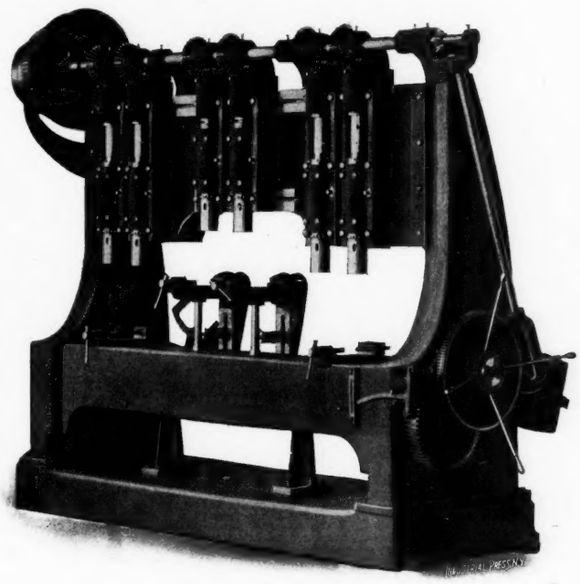
Provision is made for taking up wear and also for preventing dust from entering the bearings of the dresser, as well as for holding a supply of oil sufficient to thoroughly lubricate the bearings. The wheel used on this device has a 1½-inch face and is 3½ inches in diameter.

MULTIPLE SPINDLE DRILL FOR HEAVY WORK.

A multiple spindle drill for heavy work of a special character is the arch bar drill made by Foote, Burt & Co., Cleveland, O., which we illustrate. The uprights are cast in box form and are exceptionally deep. Each head has a 5-inch vertical adjustment so as to bring the drill points in the proper relative position regardless of whether the work is even or irregular. The cross rail is a solid web I-beam section, with cross girts on the back, and is provided with surfaces on the front to support the several heads. This cross rail is unusually rigid, to avoid deflection. The table is fed up to the drills by a rack and pinion, feed shaft being 2¾ inches in diameter, supported in each upright and in the center by two bearings. The feed rack is 4-pitch, 3 inches face. The miter gears which drive the spindles are of forged steel with planed teeth. The drive miter on each head does not depend on the drive shaft for support, but it is housed in

a heavy bearing directly connected to the saddle, and in addition to these the drive shaft is supported at four points as well as where it passes through the miter gears. The miter gears being supported in this way form a part of the head, so that when it is desirable to move the saddle for different spacing of the spindles the driving miter is carried with it. On some of the older types of this tool the saddle had to be adjusted, and the driving miter brought up separately to mesh with the driven gear, where it was fastened by a set-screw to the driving shaft, bringing the whole strain on the shaft.

The feed mechanism is extremely heavy throughout, and the whole design of the machine is such that high-speed and fast speeds can be used without straining the machine or without any apparent deflection up to the limit of the drills themselves.



Heavy Arch Bar Drill.

The capacity of the machine is for 1⅞-inch drills in any material and the spindles are 2¼ inches in diameter, making it one of the heaviest multiple spindle machines that is now built. The thrust of the drills is taken by 4-point ball bearings, with balls ⅝ inch in diameter.

PLANER RAIL ELEVATING DEVICE.

A new power elevating device has been adopted by the Cincinnati Planer Co., Cincinnati, O., for raising or lowering planer rails. The device is the invention of their superintendent, Mr. George Langen, and is operated by an improved type of friction clutch in place of the usual tumbler gears. Corresponding parts are numbered the same in the half-tone

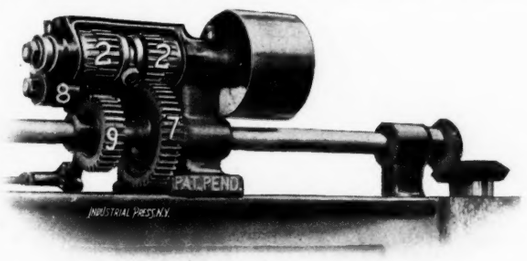


Fig. 1. Elevating Device for Cincinnati Planer (Patent Pending).

and line drawings and are as follows: 1 is the pulley shaft; 2, the driving pinions; 3, the perforated bushing driven into the driving pinions; 4, the split clutch ring; 5, a steel sleeve secured to the pulley shaft by means of a taper pin. 2 and 7 are the raising gears, while 2, 8 and 9 are the lowering gears, which are proportioned to give a higher speed than those used in raising.

It will be noted that the ends of the steel sleeve 5 are

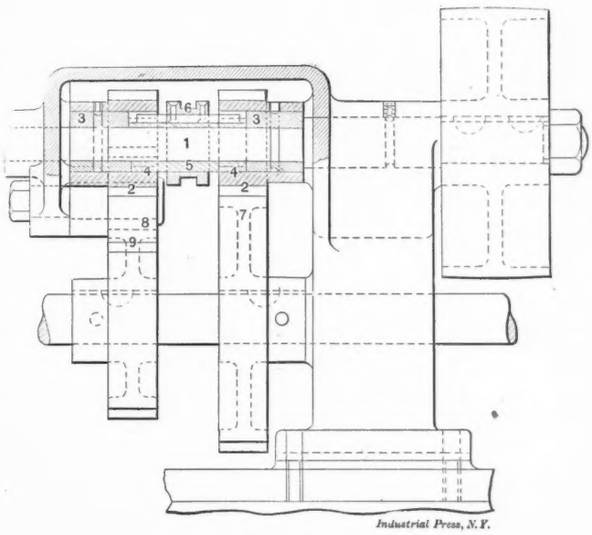


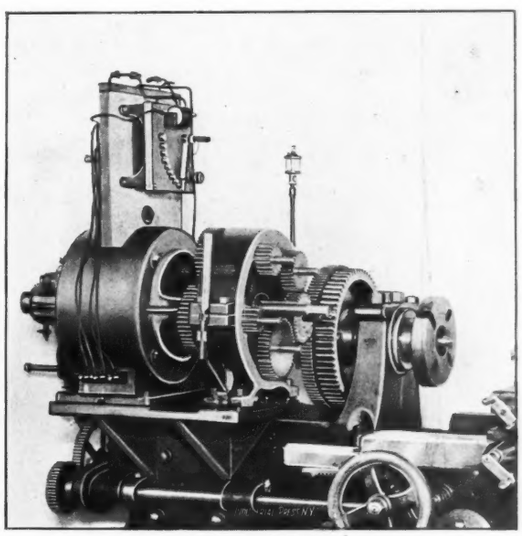
Fig. 2. Drawing of Elevating Device.

turned down so that each end fits loosely into the split ring, 4, the center being left larger in diameter so that the wedge rings cannot pull out of the gear hubs. The steel sleeve 5 is splined its entire length, and the collar 6, which operates the clutch, has a key secured to it which slides in the spline and is tapered on each end to fit the taper opening into the wedge rings and thus expands the latter. It will be noted that the design of sleeve 5 is such as to make it a simple method for holding the split rings in position.

When applied to the planer, the device is so located on the arch as to bring the raising gears directly on the center of the machine, so as to distribute the strains equally. The bracket supporting the gear also forms a center bearing for the elevating shaft. The mechanism is operated by a long handle which gives sufficient leverage to bring the device under absolute control, and it is possible to raise or lower the lathe to within scratch line of the housing. This handle is locked in position when not in use.

VARIABLE SPEED DRIVE.

The illustration herewith shows the head end of a standard lathe fitted with a Johnson mechanical speed control and a constant speed motor. The controlling apparatus is made by the Israel H. Johnson, Jr., Co., Philadelphia, Pa. This de-



Lathe Fitted with Variable-speed Drive.

vice takes the place of the usual countershaft and like the countershaft it operates at a constant speed, while the lathe spindle is driven by gearing which gives the equivalent of a 5-step cone pulley with back gearing.

The only alteration necessary in the lathe itself is the removal of the cone pulley (whatever number of steps) and

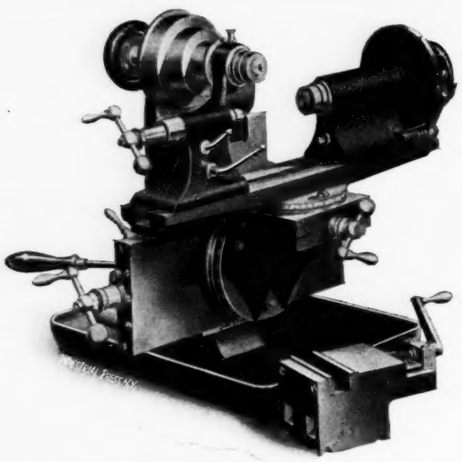
a substitution of a simple sleeve having the usual back-gear pinion on one end and at the other end a gear occupying the position of the largest step of belt cone. Connection between this sleeve and the spindle is made as in the standard lathe with cone, giving five speeds direct through spindle and five through the back gearing.

The speed control gearing has five gears mounted on shafts which pass through long bearings and carry other gears at their opposite ends.

Speed changing is accomplished by rotating the gearing housing so as to bring the desired set of gears into driving position, which is done by different methods for different sizes of speed controls. By this arrangement changes of speed are made more easily and quickly than by shifting a belt upon cone pulleys especially where the change is more than one step. One point of note in this control is that for each driving position only one pair of gears is in action, all idle gears remaining at rest.

A BENCH MILLING MACHINE.

A bench milling machine for small and accurate work has been brought out by the Sloan & Chace Mfg. Co., Newark, N. J. The elevating device of the saddle and knee is operated by a handwheel at the rear of the machine through a bevel gear and elevating screw, which thus enables the greatest knee travel possible for a given height of machine. The knee slide can be operated either by a rack and pinion or by a screw. The device for this purpose consists of a hand screw working



Bench Miller of Improved Construction.

in a cylindrical nut, with rack on one side engaging a toothed sector, to which a long handle is attached. When the nut is clamped to the knee the screw feed can be used, and when the clamp is released the slide is actuated by the long handle, which gives a sensitive lever feed. The knee and the carriage both have full circle graduated bases, one of which is in a horizontal and the other in a vertical plane. The spindle cone is for a 1-inch driving belt, and the machine has a vertical travel of 4 inches, horizontal of 8 inches, and a cross travel of 2¼ inches. The vise jaws ar 3¼ inches long and ⅝ inch deep.

TWENTY-INCH GANG DRILL FOR DRILLING AND BORING

The most recent development of the gang drill is its adaptation for drilling, boring and reaming pieces of work which ordinarily would be machined in a chucking machine. The evident advantage of a multiple spindle drill for such work is that more than one tool can be in operation at the same time. Inasmuch as different periods of time are required for the different spindles to perform the various operations upon a piece, the operator has an opportunity to set the work in

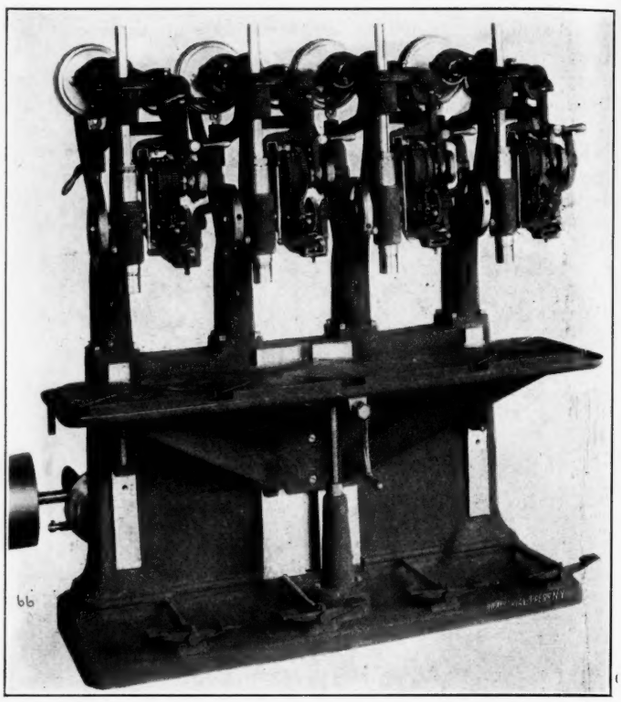


Fig. 1. Gang Drill for doing the Work of Chucking Machines.

position under each spindle, and so keep all of them in operation at the same time, as against a single spindle of the chucking machine.

The drill shown in the accompanying illustrations is made by the W. F. & John Barnes Co., Rockford, Ill. When the drill is in operation the attendant moves a lever, and the spindle instantly drops to the work and starts the drill, and when through automatically goes back to its original position. This operation can be repeated as fast as the pieces are changed and the action is the same for each of the several spindles. The machine is driven by one belt, each spindle, however, being independent of the others so that all can be operated at one time or individually.

The second illustration shows the arrangement of this driving mechanism which consists of a horizontal shaft near the floor, connected by bevel gears with a cone pulley for each spindle. The bevel gears are thrown into or out of operation by friction clutches which are operated from the front of the machine by the foot levers shown in the first illustration.

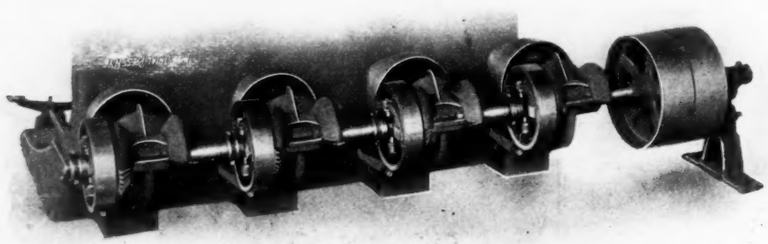


Fig. 2. Showing how all the Spindles are Driven from the same Shaft.

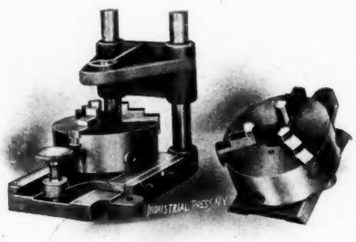


Fig 3. Chuck used in Drilling.

The universal sliding chuck shown in Fig. 3 is designed for use with this machine. The chuck is centered underneath the drill bushing by means of a taper pin. The chuck and its work are carried by a slide which can be withdrawn and placed under the different spindles for successive operations, and the chuck will always be centered.

This gang drill is made in two styles: One with the auto-